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THE SIGNIFICANCE OF DEMAND IN THE DETERMINATION OF THE PRICES OF BEEF AND PORK IN CANADA FROM 1920 TO 1932

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A great deal of confusion of thought has resulted from the drastic decline in prices from 1929 to 1933, during which period the prices of things produced by farmers for sale have fallen considerably more than the prices of the things they need to buy. Apparently consumers are paying about all that they are able to pay for food. Producers maintain that they are not receiving sufficient income to maintain production, some asserting that in many cases middlemen deliberately attempt to force prices down by means of agreements or understandings. It has been stated repeatedly within recent years that the only way to bring back prosperity is to increase substantially the income of the farmer. This idea is behind all the schemes which would restrict production or introduce so-called orderly marketing to raise the price per unit to the producer. The assumption is that the consumer can be forced to pay a higher price for the same quantity, or almost the same quantity of food out of his seriously depleted income. In the final analysis the important consideration to the farmer is not so much price per unit as it is total quantity times price per unit. It is quite conceivable that for some products a higher price per unit with smaller quantity sold might give no greater farm receipts than would come from a larger quantity sold at a lower price; thus the only advantage to be gained from the smaller volume of sales might be lower total costs. Many are questioning whether or not the small net gain would be sufficient recompense for all the costs involved in the control and supervision which would be necessary to restrict the amount sold.

No attempt is made in this paper to take issue with any particular group regarding the above contentious points, but rather to present a few observations on the domestic demand and prices paid for beef and pork since 1920. Special emphasis is given to the demand side, as it appears to be the feature which is the least understood, and possibly for that reason the most neglected in the various discussions about meat prices.

THE RELATION OF URBAN INCOMES TO URBAN EXPENDITURES FOR MEATS

The measure of urban incomes used in this analysis is total wages and salaries paid to those gainfully employed in manufacturing, mining, operating steam railroads, and construction. The method of constructing the

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TABLE 1.—DATA USED IN OBTAINING INDEX NUMBERS OF ESTIMATED TOTAL WAGES AND SALARIES PER CAPITA FOR THE URBAN POPULATION OF CANADA, 1920 TO 1932.

Year	Wages, salaries of manufacturing establishments and mining[1]		Wages and salaries steam railways[2]		Value of construction contracts awarded[3]		Index Nos. of estimated total wages, salaries of urban population 1923-27 = 100	Index Nos. of urban population[4] 1923-27 = 100	Index numbers of wages and salaries per capita of urban population 1923-27 = 100
	Millions of dollars	Index 1923-27 = 100	Millions of dollars	Index 1923-27 = 100	Millions of dollars	Index 1923-27 = 100			
1920	732.1	119.0	302.7	118.0	255.6	76.1	109.3	88.5	123.5
1921	518.8	84.4	258.2	100.7	240.1	71.5	85.8	91.6	93.7
1922	510.4	83.0	243.1	94.8	331.8	98.7	89.5	93.8	95.4
1923	571.5	92.9	264.0	102.9	314.2	93.5	95.6	95.3	100.3
1924	559.9	91.0	250.0	97.5	276.3	82.2	90.8	97.4	93.2
1925	596.0	96.9	247.7	96.6	298.0	88.7	95.0	99.8	95.2
1926	653.9	106.3	253.4	98.8	372.9	111.0	105.4	102.3	103.0
1927	693.9	112.8	267.1	104.2	419.0	124.7	113.2	105.1	107.7
1928	755.2	122.8	287.8	112.2	472.0	140.5	123.9	108.1	114.6
1929	809.0	131.5	290.7	113.4	576.7	171.6	135.6	110.9	122.3
1930	736.1	119.7	268.3	104.6	457.0	136.0	119.4	113.7	105.0
1931	624.5	101.6	229.5	89.5	315.5	93.9	96.8	116.5	83.1
1932	505.9	82.3	181.1	70.6	132.9	39.5	69.7	117.9	59.1

[1] Annual Census of Manufacturing Industries. Dom. Bureau of Statistics.

[2] Annual Reports of Railways. Dom. Bureau of Statistics.

[3] The Dom. Bureau of Statistics Reports.

In combining the index numbers of wages and salaries for manufacturing, steam railways and construction, for the purpose of constructing the total index the following weights were used: manufacturing and mining 5.2; steam railways, 2.6; construction, 2.2. According to the 1931 Census these were the proportions in which total salaries and wages were distributed to these three general types of gainful occupations.

As annual data for wages and salaries paid in the construction industry are not available it was assumed that total wages and salaries would vary approximately as the value of construction contracts awarded. This index of total demand is more accurate than one calculated by using indexes of wage rates and employment figures.

[4] The Dominion Census of 1921 reported the total population to be 8,788,000 of which 49.9% were urban. The 1931 Census reported a total population of 10,377,000, of which 53.7% were urban. The percentages of urban population for the intervening years were calculated by the straight line method between the two census periods. These percentages were then applied to the estimated total population for each year. Because of the return of many urban people to the country the normal annual percentage increase in urban population was not assumed to have taken place and the 1931 percentage of urban population was used in making the estimates for 1932.

index numbers is explained in the footnotes to Table 1, to which reference should now be made (See Table 1).

The method of calculating the relative changes in amounts spent by urban consumers for beef, veal, pork, and mutton is explained in the footnotes accompanying Table 2, to which reference is now required.

Total wages and salaries paid in Canada increased steadily from 1921 to 1929 with the exception of a small reduction in 1924. On a base of 1923-1927 = 100 this index increased from 85.8 to 135.6. On a per capita basis, this increase was from 93.7 to 122.3 (Table 1). This rise in per capita wages and salaries of 30% in 8 years was followed by a drastic drop from an index of 122.3 in 1929 to 59.1 in 1932. Preliminary data for 1933 indicate that total wages and salaries were lower than in 1932. This

TABLE 2.—STATISTICS OF URBAN CONSUMPTION AND URBAN CONSUMERS' EXPENDITURES FOR BEEF, VEAL, PORK, MUTTON AND LAMB AND ALL MEATS. INDEX NUMBERS OF ESTIMATED EXPENDITURES FOR MEAT BY THE URBAN POPULATION OF CANADA. 1920-1932.

Year	Beef		Veal		Pork		Mutton, Lamb		All Meats		
	Consumption Millions of lbs.	Expenditure Millions of dollars	Consumption Millions of lbs.	Expenditure Millions of dollars	Consumption Millions of lbs.	Expenditure Millions of dollars	Consumption Millions of lbs.	Expenditure Millions of dollars	Consumption Millions of lbs.[1]	Expenditure Millions of dollars[2]	1923 to 1927 =100
1920	263.5	78.0	24.0	6.6	211.9	11.7	24.2	8.6	523.6	204.8	108.2
1921	235.3	56.9	20.0	4.5	207.7	95.3	30.5	8.9	493.5	165.7	87.6
1922	282.3	57.9	30.5	5.7	261.7	101.8	29.9	8.2	604.4	173.6	91.7
1923	288.1	56.5	27.0	4.9	292.8	107.7	34.5	9.5	642.6	178.7	94.4
1924	279.1	53.6	31.3	5.6	321.7	102.3	23.0	6.4	655.1	167.9	88.7
1925	319.5	62.6	36.7	6.7	313.5	113.8	22.7	6.6	692.4	189.6	100.2
1926	321.7	65.9	34.4	6.6	287.9	116.9	21.9	6.5	665.9	196.0	103.4
1927	331.6	72.3	43.2	8.8	337.8	125.3	25.8	7.5	738.4	213.9	113.1
1928	316.0	79.6	40.0	9.0	371.5	133.0	31.0	9.3	758.5	231.0	122.1
1929	332.3	90.4	37.5	9.2	377.4	141.5	30.9	9.5	778.2	250.6	132.5
1930	329.8	87.7	48.1	11.4	330.5	125.3	33.7	10.2	742.2	234.7	124.0
1931	336.3	67.6	43.7	8.0	350.0	99.8	35.7	9.1	765.7	184.4	97.5
1932	307.3	51.9	43.2	6.0	396.1	70.5	36.9	7.8	783.5	136.2	72.0

[1] Data on urban consumption of meats were calculated as follows. Total dressed weight of slaughterings was taken from the Annual Reports of the Census of Manufacturing Establishments. These data include the slaughterings by all Packing Plants and Abattoirs in Canada, both inspected and uninspected exclusive of small local butchers. It was assumed that some of this meat consumed by the agricultural population would be partially offset by direct sales of farm slaughter and sales of small local butchers to urban consumers. The above data were adjusted by net imports and exports of dressed meats and changes in year to year cold storage holdings to arrive at net total consumption figures.

[2] Estimated expenditures for each kind of meat were calculated by multiplying net annual consumption figures by composite retail prices computed with varying weights for each retail cut. The retail cuts with their respective price weights were as follows:—beef, sirloin, (1); Chuck, (2); veal, leg of veal, (1); Pork, breakfast bacon, (4); Fresh pork, (1); Mutton and lamb, leg of lamb (1). These were the only annual retail quotations available in a continuous official series. It is not suggested that by this method the exact total retail expenditures for meat can be obtained. At best the annual totals will be approximate only. But the annual percentage changes of total retail expenditures will be very close to the true annual percentage changes.

severe decline in urban income, amounting to 51% in three years, takes into consideration both wage rates and unemployment and gives some indication of the recent drastic decline in domestic demand for food products. In three years the demand for farm products contracted more than it had expanded during the previous 8 years.

The variations in expenditures for meat by urban consumers follow closely variations in total wages and salaries (Figure 1). During the past 13 years expansion and contraction of total wages and salaries apparently have governed to a remarkable degree the amount that consumers have spent on meats. For the 13 year period the coefficient of correlation between total wages and salaries and expenditures for meat was $+.98 \pm .007$. In the case of the expenditures for pork alone the correlation was $+.967 \pm .019$; and for beef alone $+.93 \pm .039$. For veal and mutton the expenditures appeared to lag about a year behind changes in wages and salaries. Comparing the wages of the year previous with current expenditures for veal the correlation was $+.779 \pm .118$; and for mutton $+.671 \pm .166$.

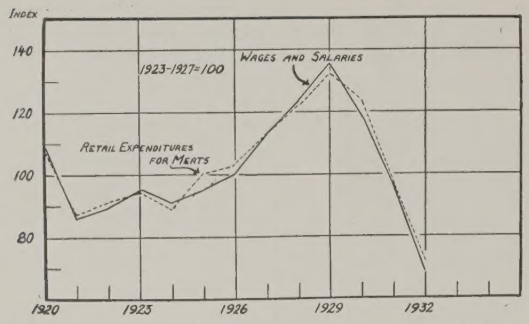

FIGURE 1. Annual changes in index numbers for wages and salaries of the urban population and urban expenditures for meat. Canada, 1920-1932. Total expenditure for all meats tends to fluctuate closely with total wages and salaries.

As wages and salaries decline there is a tendency for a slightly higher percentage of the income to be spent on meats, and as wages and salaries increase there is a tendency for a slightly lower percentage of the total income to be spent on meat. When wages are cut severely food is the last item of expense to be reduced, whereas when wages rise a larger proportion of the income, after food requirements have been met, will be spent on things other than food.

As the incomes of the consumers fluctuate closely with their expenditures for meats, it should not be assumed that a given percentage increase or decrease in income would be accompanied by an equal increase or decrease in total farm income from livestock sold. Because of the many fairly rigid costs between the producer and the ultimate consumer, increases or decreases in consumers' incomes are reflected in relatively greater changes in total farm incomes obtained from sales of food products. The response of total farm incomes from different meats to changes in total wages varies with the elasticity of demand for the individual commodity. This question will be discussed later.

A certain degree of substantiation of the above discussion of the relationship between consumers' expenditure for meats and consumers' incomes is indicated by fairly recent research of Bean (*1*). Using annual data from 1920 to 1932 he showed that for the United States retail values of the consumption of pork, beef, mutton and creamery butter bear strikingly high correlations to indexes of consumers' incomes. Using monthly data L. H. Bean and Mordecai Ezekiel showed that the combined farm cash incomes from meat animals, dairy products and poultry products from 1924 to 1933 were highly correlated with pay rolls (*3*). The conclusions reached by these writers were as follows:—"Returns to farmers for their marketings of farm products depend by and large on the money income of consumers in general. This is particularly true of returns from the production of meat animals, dairy and poultry products, and other commodities, that are sold chiefly in domestic markets. . . . . "

THE EFFECT OF DEMAND, AS REPRESENTED BY WAGES AND SALARIES, ON PRICES PAID FOR BEEF

In order to isolate as far as possible the effect of demand on prices paid for beef it was necessary to explain all or nearly all of the variations in the prices paid for beef during the 13 years 1920 to 1932. The statistical method used was the graphic curvilinear correlation method developed by

Bean (*2*). It was found that practically all the variations in prices[2] paid for beef during these years could be explained by the following six factors; (1) the supply of beef;[3] (2) wages and salaries per capita; (3) exports of cattle;[4] (4) supply of pork; (5) supply of mutton; and (6) time. The uncorrected index of multiple correlation between these six factors and the price of beef was .987, indicating that 97.4% of the variations in price were accounted for. In measuring the approximate influence of the six factors three measures are shown in Table 3; (1) the maximum range in cents per pound for each factor during the 13 years; (2) the total price variation for each factor measured as deviations from the average readings of the respective curves; and (3) these respective price variations expressed as a percentage of the total price variations. From this table it will readily be seen that 54% of the variations in prices of beef could be attributed to wages and salaries; 16% to the supply of beef; 13% to supply of pork; 8% to exports of cattle; 6% to supply of mutton and 3% to time, or an upward trend of demand from 1920 to 1932.

The striking fact is the strong influence of demand which was responsible for three times as much price variation as the supply of beef, and appeared to be considerably more important than the combined influence of the supply of beef, pork, and mutton. However consideration must be given to the fact that the 13 years, from 1920 to 1932, are heavily weighted with three years with wages and employment at very high levels (1920, 1928 and 1929) and three years (1921, 1931 and 1932) of very low wages and considerable unemployment. Because of the rapid changes in wages and employment during these years it is natural to expect that demand would have considerable influence on the prices paid for meats. Had a longer period been studied in which fluctuations in employment and wage rates had been less violent, demand might have had less influence in the determination of prices.

The separate net effect of each factor is shown in the curves in Figure 2. The most important curve and the one with which we are most concerned is that for demand (X_3). When total wages were comparatively low the first increases of wages did not cause a very great increase in demand for beef. After a certain point had been reached however, further increases in total wages and salaries resulted in a rapid rise in demand. When wages and salaries reached a comparatively high level further increases caused very little change in the demand for beef. These phenomena might be explained by the fact that in a time of depression, although wages are low and unemployment is widespread, comparatively few people actually experience acute shortage of food while many suffer from deficiency of clothing and lack of attention to health requirements. Upon the resumption of gainful employment the workers pay early attention to these neglected items. After these wants are satisfied further increases in incomes go partly to a higher level of food consumption. Eventually a

[2] Annual prices paid for beef and pork as used in this study are annual average prices per pound dressed for all meats purchased by all the packing plants in Canada, including both uninspected and inspected plants, excluding small local butchers. Gross amounts and value are published annually in the Annual Census of the Meat Packing Industry by the Dominion Bureau of Statistics. The prices paid per pound were calculated by dividing the annual data of total value by the annual data of total weight in pounds. For beef the price is that for total weight of beef and veal combined.

[3] Supply of beef, pork and mutton as used in this study is the total weight of dressed meats purchased by the packing plants as indicated above expressed as percentages of trend to eliminate the upward trend of supply from 1920 to 1932. For beef the supply includes veal purchased.

[4] Exports of cattle were adjusted to include veal calves for which a weight of one-fifth was given.

TABLE 3.—FACTORS AFFECTING THE PRICE OF BEEF AND VEAL

Year Time X_7	Supply of beef X_2	Demand X_3	Export of cattle* X_4	Supply of pork X_5	Supply of mutton X_6	Readings from respective curves (cents per pound) X_2	X_3	X_4	X_5	X_6	X_7	Estimated price	Actual price beef X_1	Difference
1920	+ 1.0	123.5	260.0	− 9.0	− 0.6	11.2	+4.4	+0.6	+0.8	0.0	−0.3	16.7	16.8	+0.1
1921	−14.2	93.7	189.0	−20.4	+13.2	13.1	−2.6	0.0	+2.0	−0.2	−0.2	12.1	12.1	0.0
1922	+ 0.2	95.4	220.0	− 7.0	+15.3	11.2	−2.4	+0.3	+0.5	−0.2	+0.2	9.2	9.0	−0.2
1923	− 3.6	100.3	167.0	+ 1.4	+18.9	11.7	−1.8	−0.5	0.0	−0.2	−0.1	9.1	9.1	0.0
1924	− 2.7	93.2	192.0	+24.5	−15.5	11.6	−2.6	0.0	−0.4	+0.4	−0.1	8.9	8.7	−0.2
1925	+ 6.3	95.2	219.0	+18.7	−21.9	10.5	−2.5	+0.3	−0.2	+1.0	0.0	9.1	9.3	+0.2
1926	+ 7.9	103.0	192.0	+ 6.0	−23.3	10.3	−1.0	0.0	0.0	+1.0	0.0	10.3	10.1	−0.2
1927	+15.3	107.7	236.0	+ 8.0	− 9.9	9.6	+1.5	+0.4	0.0	+0.1	0.0	11.6	11.6	0.0
1928	+ 6.1	114.6	188.0	+ 4.9	− 1.1	10.5	+4.1	0.0	0.0	0.0	+0.1	14.7	14.9	+0.2
1929	+ 4.6	122.3	185.0	− 1.2	− 1.1	10.7	+4.4	0.0	0.0	+0.0	+0.1	15.2	15.0	−0.2
1930	− 4.7	105.0	36.0	−20.2	+ 4.0	11.9	+0.1	−0.8	+2.0	0.0	+0.2	13.4	13.5	+0.1
1931	− 3.2	83.1	44.0	− 9.7	+15.0	11.7	−3.3	−0.8	+1.0	−0.1	+0.2	8.7	8.9	+0.2
1932	−11.7	59.1	29.0	+ 4.3	+ 6.3	12.8	−4.9	−0.8	0.0	−0.1	+0.3	7.3	7.2	−0.1
Standard deviation												2.84	2.87	
(1) Maximum range						3.5	9.3	1.4	2.4	1.2	0.6			
(2) Total price variations attributed to each factor						10.1	34.2	4.9	8.1	3.8	1.8	(cents per pound)		
(3) Percentage of price variations attributed to each factor						16.0	54.0	8.0	13.0	6.0	3.0			

*Thousands of cattle.

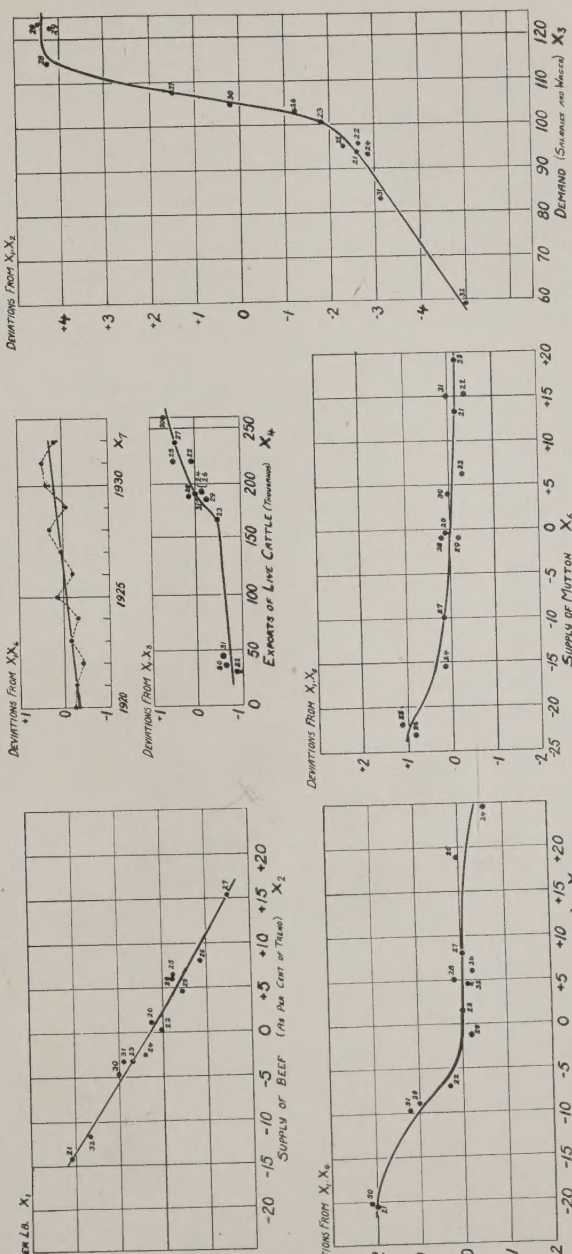

FIGURE 2. Factors affecting the price paid by packers for beef. Canada, 1920 to 1932.

point is reached when further increases in salaries go into luxury and semi-luxury goods rather than food. In support of this explanation the wage curve (X_3) indicates that the increase in demand for beef rose slowly at first, and became stronger as wages and salaries picked up, tapering off as payrolls reached a high level.

Two years, 1921 and 1930, were largely responsible for the comparatively strong influence of the supply of pork on the price of beef (Figure 2). It is just possible that the short period on which this study is based might tend to overemphasize the importance of this factor. The only years that appeared to influence beef prices to any appreciable extent were years in which there was a very short supply of pork, such as 1921 and 1930. Years of large supply of pork appeared to have little influence on the price of beef.

The small influence of mutton supply on beef prices was limited to two years of very low supply, 1925 and 1926.

Exports of cattle have been fairly important in determining the price paid for beef, the greater the exports the higher being the price. Since the war, with the exception of the years 1930, 1931 and 1932, Canada has exported annually at least 150,000 head of cattle. Apparently Canada produces annually a surplus of cattle over its domestic requirements and requires an outlet for at least 150,000 head to maintain domestic prices at a reasonable level. In this statistical study it must be clearly understood that these curves are net effect curves which are obtained by simultaneously holding the other factors constant at their average values. The curve showing the net effect of exports of cattle (X_4) would indicate that, holding all the other factors constant at their average values of the 13 years, an increase in exports of live cattle from 50,000 head to 250,000 head would have resulted in an increase in prices paid for beef of 1.25 cents per pound.[5]

The residual variations in price unaccounted for by the first five factors when plotted against time (X_7) (i.e. 1920 to 1932) had a definite upward trend. This apparently indicates that apart from the influence of the other factors discussed there has been a tendency during the 13 years for an upward secular trend in demand. That is to say, there has been a gradual tendency for consumers to pay a slightly higher price for the same quantity of beef or to pay the same price for a slightly greater quantity of beef. This is distinctly apart from any increase in wages or employment. In the 13 years this increase amounts to 0.6 cents per pound dressed or about 0.3 cents live weight. At this rate of increase it would take 40 years to show an increase of 1 cent per pound live weight due to a gradual change in demand. There are a number of possible reasons for this secular trend in demand but they cannot be enlarged upon in this article.

Murray in a study of factors affecting the price of fat cattle in England from 1893 to 1925 (*5a*) found that the purchasing power of wages accounted for 70% of the variations in the purchasing power of fat cattle, and supply

[5] At this point it is advisable to indicate one of the limitations of multiple correlation analysis. The assumption of multiple correlation is that in measuring the net effect of any one independent variable the other variables are held constant at their average value. But when the effect on the dependent variable (price in this case) due to changing one independent variable is dependent upon the magnitude of another independent variable, multiple correlation will not state the true relationship. In the case above it is quite possible that the net effect of export of cattle on the domestic price depends upon the level of demand at the time. In other words, an increase in exports of cattle from 50 thousand to 250 thousand head with a very low level of domestic demand might raise domestic prices more than when domestic demand is at a high level. This would be an example of joint correlation. For further comments on this matter the reader is referred to Cornell University, memoir, 141: "Multiple Correlation Analysis as Applied to Farm Management Research." by Stanley W. Warren, May 1932.

accounted for 14%. The wage index used was based on wage rates and so the total annual wage payments were not taken into consideration.

THE EFFECT OF DEMAND ON PRICES PAID FOR PORK

Four factors were found to explain practically all the variations in dressed hog prices from 1920 to 1932; supply of hogs (X_2); demand (X_3); exports of bacon, ham and fresh pork (X_4); and exports of lard (X_5). The unadjusted index of multiple correlation using these four factors was .998 which indicates that for the 13 years practically all the price variations were accounted for. Demand, and exports of bacon, hams and pork were of equal importance, 30% of the price variations being attributed to each of these two factors (Table 4). Of the other factors, 28% of the variations in price were attributed to supply and 12% to export of lard.

The residual unexplained price variations after allowing for the effect of the first three factors, X_2, X_3, X_4, were plotted against various independent variables in an effort to explain them. They did not show any trend when plotted against time. This would indicate that unlike beef there was no gradual upward secular trend in the demand for pork.[6] The residuals were also plotted against the supply of beef as used in the beef price analysis. There appeared to be a positive correlation which on the surface might be considered to indicate that the price of pork increased with an increase in supply of beef, which of course is illogical, making further investigation necessary. During the period 1920 to 1932 there was a positive gross correlation between supply of beef and price of beef which was itself correlated with the unexplained differences in pork prices. That is to say in most years the price of beef increased at the same time that the supply purchased by all the packing plants of Canada was increasing, and also decreased when the supply of beef fell off. This positive correlation however was due to the strong influence of demand during these few years, rising from 1921 to 1929 and falling in 1920, 1931 and 1932. As beef prices were in themselves correlated with demand (X_3), being largely determined by demand during the period studied, it was decided not to include two independent variables (demand and price of beef) that are in themselves so highly correlated. Because the exports of lard were found to explain fairly well the residual variations they were included as variable (X_5). It is not suggested that exports of lard actually have as much influence on pork prices as indicated by Table 4, as apparently a considerable portion of that influence is caused by the price of beef, the net effect of which it was not possible to isolate by this analysis. Much greater reliance can be placed on the importance of supply, demand, and exports of pork than on exports of lard in the determination of pork prices.

The net curves for each factor are shown in Figure 3. The supply curve for pork has a somewhat steeper slope than that for beef. The curve for wages and salaries (X_3) is very similar in shape to the one for this factor in the beef analysis. The curve of net effect for exports (X_4) is very significant, indicating a strong and favourable influence on domestic prices, especially after the exports reached about 100 million pounds per year.

[6] In this connection it is of interest that the purchasing power of hogs (i.e. price of hogs divided by the wholesale index) from 1920 to 1932 does not show any upward trend. From 1870 to 1921 the purchasing power of hogs shows a strong upward trend and it is conceivable that if it were possible to isolate each of the important factors affecting the price of hogs in Canada from 1870 to 1921 that an upward trend in demand would be found, similar to the trend in demand for beef from 1920 to 1932.

TABLE 4.—FACTORS AFFECTING THE PRICE OF PORK

Year	Price	Supply of pork as % of trend X_2	Demand X_3	Exports of bacon, ham, and pork, millions of lbs. X_4	Exports of lard, millions of lbs. X_5	Readings from respective curves (cents per pound) X_2	X_3	X_4	X_5	Estimated price	Actual price	Difference
1920	26.0	− 9.0	123.5	109.4	7.6	15.9	+5.9	+2.4	+1.9	26.1	26.0	−0.1
1921	17.8	−20.4	93.7	106.1	3.1	19.2	−2.3	+1.8	−0.9	17.8	17.8	0.0
1922	15.6	− 7.0	95.4	100.8	4.8	15.4	−2.0	+0.9	+1.0	15.3	15.6	+0.3
1923	13.1	+ 1.4	100.3	103.6	4.3	13.0	−0.8	+1.4	−0.3	13.3	13.1	−0.2
1924	11.5	+24.5	93.2	128.1	5.3	6.7	−2.4	+5.6	+1.6	11.5	11.5	0.0
1925	15.8	+18.7	95.2	149.8	10.6	8.4	−2.1	+7.5	+2.0	15.8	15.8	0.0
1926	17.1	+ 6.0	103.0	110.0	6.5	11.8	+0.6	+2.7	+1.9	17.0	17.1	+0.1
1927	13.9	+ 8.0	107.7	82.6	4.8	11.3	+2.8	−1.2	+1.0	13.9	13.9	0.0
1928	13.5	+ 4.9	114.6	52.4	1.0	12.1	+5.5	−2.7	−1.4	13.5	13.5	0.0
1929	15.3	− 1.2	122.3	39.0	1.5	13.7	+5.9	−3.2	−1.3	15.1	15.3	+0.2
1930	15.2	−20.2	105.0	20.5	0.2	19.0	+1.6	−3.8	−1.6	15.2	15.2	0.0
1931	9.2	− 9.7	83.1	17.5	4.7	16.1	−3.6	−3.9	+0.8	9.4	9.2	−0.2
1932	5.9	+ 4.3	59.0	46.0	4.9	12.3	−4.6	−2.9	+1.2	6.0	5.9	−0.1
Standard deviation										9.36	9.38	
(1) Maximum range						12.5	10.5	11.4	3.6	(cents per pound)		
(2) Total price variation attributed to each factor						37.2	40.4	40.6	15.4			
(3) Percentage of price variations attributed to each factor						28.0	30.0	30.0	12.0			

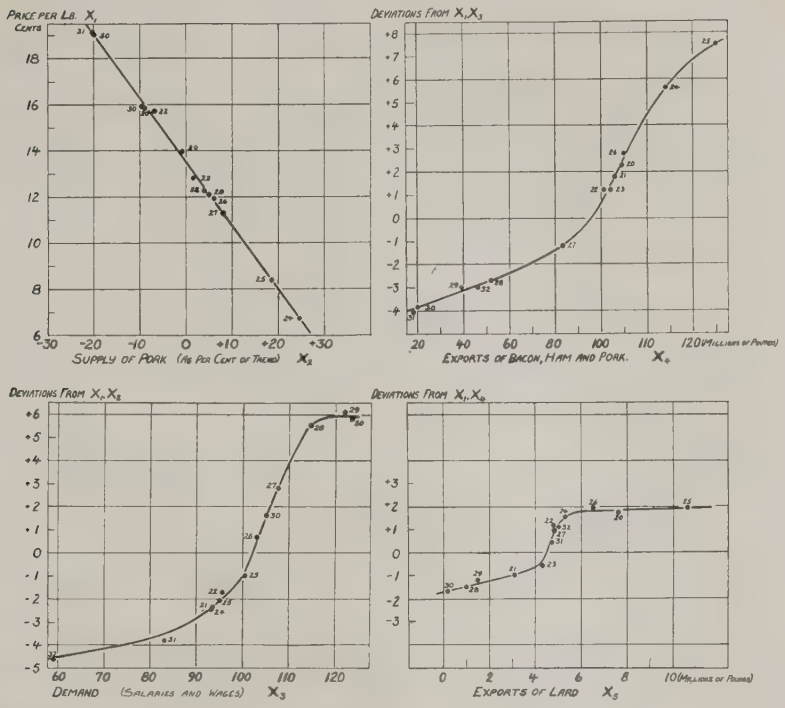

FIGURE 3. Factors affecting the price paid by packers for pork. Canada, 1920 to 1932.

The curve for lard exports indicates the maximum effect of lard exports on the price of pork during the past 13 years to be reached at about 6 million pounds, any increase beyond that point not resulting in any significant increase in prices.

The method of price analysis as presented in this paper is somewhat different from the method followed in most price studies. In order to remove the effect of changing price levels the prices are usually adjusted by dividing by the wholesale index. As a measure of demand, usually some measure of industrial activity has been used instead of wages actually paid. Haas and Ezekiel in a statistical study of factors affecting the price of hogs from 1903 to 1914 (*4*) using the purchasing power of hogs as the dependent variable, found that 32% of the variations in the purchasing power of hogs were due to supply and only 5.7% due to business activity as measured by an index of stock market prices. An index of stock market prices cannot be considered a reliable measure of the total purchasing power available in the country from year to year, as the authors concede in their statement that undoubtedly a great deal of industrial activity is concealed in a rise and fall of the general price index. By using the purchasing power of hogs instead of the actual price of hogs that portion of business activity which is included in changes in the price level is hidden. The 5.7% effect

of industrial conditions very much under-estimates the true influence of the purchasing power of consumers.

Murray (*5b*) in studying the factors affecting the purchasing power of pork in England from 1890 to 1927 found that 85% of the variations in purchasing power could be attributed to the number of pigs in Great Britain, and 3·6% to imports of pork into Great Britain. In the case of English bacon, 44.8% of the variations in purchasing power were attributed to the number of pigs in Great Britain and 21.2% to imports of bacon. In both cases the effect of business conditions, or demand as represented by changes in price levels was not measured.

RELATION OF SUPPLY AND PRICE

In Figure 4 are shown the two supply price curves for beef and pork. The prices have been expressed as percentages of the average for the period and supply expressed as percentages of normal (*i.e.*, trend). It will be noticed that the supply curve for pork has a much steeper slope than for beef, indicating the prices paid by the packers for pork are more sensitive to supply than prices paid for beef, which in turn would indicate the consumption of pork is more sensitive to retail price changes than is the consumption of beef. However further analysis of consumption data and retail prices would be necessary to establish this point.

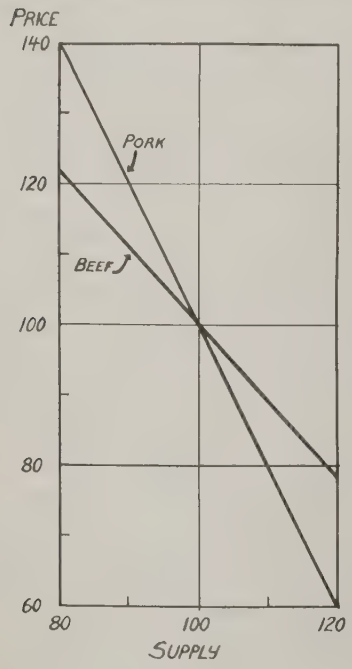

FIGURE 4. The relation of supply and price of beef and pork purchased by packing plants. Canada, 1920 to 1932. When the supply of pork was 20% below normal, prices paid by packers were 40% above normal. When the supply of beef was 20% below normal the prices paid by packers were 22% above normal.

It is of interest to compare the flexibility of prices for beef and pork in Canada, the United States and Great Britain. During the post-war period a supply of pork 20% below normal in Canada resulted in the packers paying a price 40% above normal; in the United States during the period 1890 to 1914 such a decrease resulted in prices 21% above normal at Chicago; in Great Britain during the period from 1890 to 1927 (omitting the years 1915 to 1921) a supply of home produced pork 20% below normal made wholesale market prices 22% above normal. For beef, a supply 20% below normal in Canada resulted in the packers paying a price 22% above normal during the post war period; in the United States from 1890 to 1914 a supply 20% below normal resulted in prices at Chicago 17% above normal and prices on the farm 39% above normal; in Great Britain from 1892 to 1919 a supply of cattle 20% below normal resulted in a price 20% above normal.

The flexibility of prices in the three countries, as disclosed in Table 5, is not exactly comparable as the prices used in the United States and Great Britain were both expressed in terms of purchasing power. In the case of the United States the period studied was before the war, and for Great Britain very few post-war years were included. If both these studies were repeated for the period 1920 to 1932 the price changes would probably have been more violent because of the relatively greater increase in the costs of distribution compared with the prices of beef and pork.

Some indications of the relative position of the livestock industry in Canada under conditions of a large or a small supply can be obtained by use of the data in Table 5. For a supply of pork 80% of normal the packers

TABLE 5.—EFFECT OF CHANGES IN THE SUPPLY ON PRICES PAID FOR BEEF AND PORK IN CANADA, UNITED STATES AND GREAT BRITAIN

Commodity	Supply 20 per cent: below normal	Supply 20 per cent: above normal
	Per cent that prices were: above normal	Per cent that prices were: below normal
PORK:		
Canada. 1920-1932. Prices paid by packers	40	40
United States*. 1890-1914. Prices paid at Chicago for West winter hog pack. Nov.-Feb.	21	15
Great Britain.† 1890-1914 and 1922-1927. Prices paid for home produced pork...	22	15
BEEF:		
Canada. 1920-1932. Prices paid by packers	22	22
United States*. 1890-1914. Prices paid at Chicago	17	12
United States farm prices..	39	24
Great Britain.† 1892-1919. Prices paid on the London market for first quality beef	20	14

*United States data from "Inter-relationships of supply and price, p. 112, Cornell University, Agricultural Experiment Station, Bulletin 466. March, 1928.

†Data for Great Britain from "Factors affecting the prices of livestock in Great Britain, p. 69 and 149. University of Oxford, Agricultural Economics Research Institute. 1931.

paid a price of 140% of normal. The total value may therefore be represented by 80% of 140, or 112. For a supply of pork 120% of normal they paid a price 60% of normal, or a total value of 72. Similarly for a supply of beef 80% of normal they paid 98 and for a supply 120% of normal they paid 94. In both cases the gross amount paid was less for the large supply than for the small supply. Because freight and commission would be less for the small amount than for the large amount, the farming community received considerably more for the small amount, than for the large supply, besides having lower total costs for the small amount. This is chiefly due to the approximate unit elasticity of retail demand for beef and pork indicated in the first part of this paper. That is to say there is strong evidence that total consumer expenditure for meat tends to contract and

expand almost proportionally with incomes irrespective of the amount consumed, or the amounts purchased by the packers.

Any remarks on the relation between supply and gross farm value of any commodity must go further than the mere statement that small supplies of a given commodity return the farmer larger gross receipts than a large supply. Timoshenko, using data for the United States (*6*) has indicated that a high ratio of agricultural prices to industrial prices often precedes or is coincident with a business recession. On the other hand a low ratio of agricultural to industrial prices generally precedes or coincides with a business revival. He also shows that the high ratio of agricultural to industrial prices is often caused by small crops from which gross receipts from farm sales are usually at a high level. The low ratio of agricultural to industrial prices is coincident with large crops when the gross receipts of farmers are smaller. From his study it appeared that business recession was coincident with high agricultural purchasing power, and revival coincident with low agricultural purchasing power.

This leads one to believe, that with demand remaining the same, although in periods of small supply of crops or livestock the gross farm income is higher than in periods of large supply, the repercussions on industry as a whole are decidedly unfavourable. In periods of small supply all branches of the systems of transportation and distribution of agricultural commodities undoubtedly experience a comparatively low income. For that reason industrial purchasing power arising from the processing and distribution of agricultural products is considerably lower than when agricultural production is at a high level. This purchasing power caused by a small volume of agricultural production is ultimately reflected back in a reduced demand for agricultural products. In the long run the minimum of deviations from trend of the supply of farm products would be most beneficial to agricultural and non-agricultural groups.

SUMMARY

1. Total annual expenditures by urban consumers in Canada for all meats tend to vary almost directly with changes in the demand for these products as indicated by annual totals of wages and salaries.

2. From 1920 to 1932 annual changes in prices paid by all packing plants in Canada for beef and veal and pork have been largely determined by changes in domestic demand as represented by total per capita wage and salary payments of the urban population. For beef and veal domestic demand was responsible for three times as much price variation as supply. Domestic demand, supply and exports were about of equal importance as price making factors in the case of pork.

3. Prices paid by packing plants for pork were more sensitive to supply than prices for beef.

4. Supply price curves for beef and veal, and pork indicate that, other things being equal, farmers as a group receive more gross income from a small supply than from a large supply.

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Résumé

L'effet de la demande sur la détermination des prix du bœuf et du porc au Canada de 1920 à 1932. E. C. Hope, Professeur-adjoint de l'exploitation de la ferme, Université de la Saskatchewan.

Le montant total dépensé annuellement sur l'achat de toutes les sortes de viandes par les consommateurs urbains au Canada tend à varier presque directement avec les changements qui se produisent dans la demande pour ces produits, indiqués par les totaux annuels payés en gages et en salaires. De 1920 à 1932, les changements annuels dans les prix payés par toutes les salaisons au Canada pour le bœuf, le veau et le porc ont été réglés en grande partie par les changements de la demande domestique, influencés par le montant total payé en gages et en salaires à la population urbaine. Pour le bœuf et le veau la demande domestique a eu trois fois plus d'effet que l'offre sur la variation de prix. La demande domestique, l'offre et les exportations avaient à peu près une importance égale au point de vue de l'effet exercé sur les prix dans le cas du porc. La quantité offerte a exercé plus d'effet sur les prix payés aux salaisons pour le porc que sur les prix payés pour le bœuf. Les courbes de prix pour le bœuf, le veau et le porc indiquent que dans des circonstances égales les cultivateurs, en tant que groupe, tirent toujours un plus gros revenu brut d'un petit approvisionnement que d'un gros approvisionnement.

INVESTIGATIONS ON BLACK KNOT OF PLUMS AND CHERRIES, II.

THE OCCURRENCE AND SIGNIFICANCE OF CERTAIN FUNGI FOUND IN ASSOCIATION WITH *DIBOTRYON MORBOSUM* (*SCH.*) T. & S.[1]

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It is a well-known fact that certain fungi occur with certain other fungi in associations varying from apparently perfect symbiosis on the one hand to complete parasitism on the other. During the course of an intensive investigation of black knot several members of the Fungi Imperfecti appeared consistently in isolations from knot tissues. At first these fungi were considered to be possible imperfect forms of *D. morbosum* (Sch.) T. & S. Later, when it had been definitely shown that they bore no genetic relationship to the black knot fungus the significance of their association with the organism causing the disease was investigated. The results of observations and experiments in this connection are reported in the present article.

REVIEW OF LITERATURE

A survey of the literature in connection with studies on black knot shows that various fungi have been found associated with knots. Farlow (*5*) in 1876 reported the fungus *Trichothecium roseum* on knots and expressed the opinion that it was parasitic on exudant gum on the surface of the knot, and later on the knot stroma. Since that time this fungus has been reported frequently on knots and has been considered to be either a parasite or a saprophyte on the knot stroma. Farlow (*5*) also described several other fungi which he found consistently associated with knots. One of these, which has since been named *Hendersonula morbosa* Sacc., was considered by him to be an imperfect stage of *D. morbosum*. Weir (*17*) in 1914 stated that the cankers formed by the black knot parasite on Prunus and Amelanchier are frequently infected by *Fomes igniarius*. This additional irritation, he states, causes the formation of large burls of very irregular shape and of a peculiar structure. He also reported the frequent occurrence of *Nectria cinnabarina* Fr. on knots. Humphrey (*8*) in 1913 reported a pycnidial-producing fungus associated with knots. He claimed to have obtained this fungus from ascospores and concluded that it was genetically connected with *D. morbosum*. Judging from his description and drawings this fungus was undoubtedly a *Coniothyrium* sp., though he did not assign it to this genus.

Heretofore the significance of the occurrence of the various fungi found in association with black knot has received little or no consideration. In other diseases, however, the literature reporting associations of fungi, which vary from symbiosis to pure parasitism is extensive. The parasitism of *Cronartium ribicola* by *Tuberculina maxima* which has been investigated by Tubeuf (*15*) and others in Europe, and recently by Mielke (*11*) in America

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is a good example. Other interesting instances of the same phenomenon are numerous, *e.g.*, the parasitism of ascocarps of Elaphomyces by species of Cordyceps (Gwynne-Vaughan and Barnes (*7*)); also *Trichoderma lignorum* which was found by Weindling (*16*) to parasitize other soil fungi. Various relationships between bacteria and fungi have been reported. Petri (*12*) in 1927 described a bacterium which penetrates and destroys the hyphae of *Phytophthora* and *Pythiacystis* species. Sanzone (*14*) in 1929 reported a bacterium which lives symbiotically within the hyphae and conidia of *Fusarium solani* (Mart.) Sacc. Johnson (*9*) and Bamberg (*1*) investigated fully the antibiosis of certain bacteria to smut fungi. Burkholder and Guterman (*3*) reported an interesting instance of synergism in a bacterial disease of *Hedera helix*. Machacek (*10*) in carrying out extensive work with different pairs of fungi found examples of (*1*) mutual tolerance and (*2*) partial or complete inhibition of one by its associate. Sanford and Broadfoot (*13*) demonstrated that many soil-inhabiting fungi and bacteria were effective in suppressing the pathogenicity of *Ophiobolus graminis*. Fawcett (*6*) in 1931 summarized to date investigations in connection with known mixtures of micro-organisms.

CEPHALOTHECIUM ROSEUM CORDA (TRICHOTHECIUM ROSEUM LINK) ON BLACK KNOTS

This fungus appears consistently each year in July and August on the surface of the conidial-bearing stroma of knots on *Prunus domestica* L. and is readily recognized by its delicate, pink colour (Plate II, Figure 1). It is apparently widespread in its occurrence, having been observed in various parts of Ontario on knots on the cultivated plum at the above-mentioned time of year. It is also present on knots on *Prunus pennsylvanica*, *P. virginiana*, *P. Maacki*, *P. americana* and *P. domestica* in all provinces from Prince Edward Island to Manitoba. Its presence on the knot is restricted in certain cases to localized areas while in others it completely overruns the fruiting surface, the whole knot being covered with the pink mycelium. Monosporous cultures of the organism were obtained and identified as *Cephalothecium roseum*, Corda.

Infection Experiments

In order to ascertain whether or not *C. roseum* is parasitic on stroma of *D. morbosum* knots which appeared macroscopically to be free from the fungus were chosen for inoculation. A summary of these experiments is given in Table 1. The Cephalothecium conidia in a water suspension were applied with an atomizer to the surface of the knots as in experiments 1 and 2, or by means of a camel's hair brush as in experiment 3, or simply transferred in the dry condition also by means of a camel's hair brush as in experiment 4. Checks were made for each experiment. In experiments 1, 2 and 3 all knots were covered with cellophane bags for three to four days. All infection experiments were conducted a short time previous to the appearance of abundant natural infection in order to minimize as much as possible the infection of checks.

It will be observed in Table 1 that all inoculations of knots with *C. roseum* resulted in infection. Within ten days on all knots either certain areas or the complete fruiting surfaces of *D. morbosum* became covered with the pink mycelium of *C. roseum*. This was true even in cases where

TABLE 1.—RESULTS OF INFECTION EXPERIMENTS IN WHICH BLACK KNOTS WERE INOCULATED WITH *Cephalothecium roseum*

Expt. No.	Date	No. of knots		Results
		Inoculated	Check	
1	7.7.31	5	—	Knots covered with pink mycelium ten days later.
		—	5	No change.
2	9.7.32	5	—	Knots showed presence of localized pink areas fourteen days later.
		—	5	No change.
3	12.7.32	6	—	Knots completely covered with pink mycelium ten days later.
		—	6	Two knots showed small pink areas seven days later. In others, no change.
4	5.7.33	10	—	Localized pink areas on all knots fourteen days later.
		—	10	Three knots showed small pink areas ten days later.

spores were painted on the surface of the conidial-bearing stroma without the addition of water. It will also be noted that a few checks became infected. However, they always manifested a lesser degree of infection by *C. roseum* than those artificially inoculated, which indicated that they probably became infected naturally at some time subsequent to the date of inoculation.

Observations which were made on all of the above inoculated knots in November of the year of infection showed in the first place that the pink, mycelial mat had in most cases disappeared, and secondly, that the knots had resumed their normal, dark colour. Moreover, the perithecia of *D. morbosum* had also vanished leaving only a rough, blackened surface on the knots, which on examination proved to consist of the bases of the original perithecia. The perithecial initials already formed at the time of the attack had been destroyed. Check knots not naturally infected with *C. roseum* or other fungi in the intervening time, manifested the presence of a normal number of immature perithecia.

Cultural Investigations

To confirm the results of the infection experiments, and to obtain information regarding the method of parasitism of *D. morbosum* by *C. roseum*, both fungi were grown as associates in cultures.

Petri dishes containing 10 cc. of potato dextrose agar were inoculated first with conidia of *D. morbosum*. After the colonies became about one half inch in diameter they were inoculated with conidia of *C. roseum*. In a few days the colonies of *D. morbosum* became completely covered with the pink mycelium of Cephalothecium. The latter continued to grow while the growth of the Dibotryon colony was permanently arrested.

When Dibotryon was allowed to grow until it filled the Petri dish after which it was inoculated with *C. roseum*, the latter grew readily, produced abundant conidia and covered the dark green conidial mat with

a pink mat of mycelium in a manner very similar to that on the host outdoors (Plate II, Figure 3). In the final set of experiments spores and aerial mycelium of Petri dish colonies of *D. morbosum* were removed and placed in dry, sterile Petri dishes. To these were added suspensions of conidia of Cephalothecium in a small amount of distilled water. The spores of *C. roseum* germinated and produced a fair abundance of mycelium and spores throughout the mass of Dibotryon conidia, while spores of the latter apparently did not even germinate. Numerous examinations of these cultures showed that the mycelium of *C. roseum*, on making contact with that of *D. morbosum*, frequently became enlarged but did not actually invade the hyphae of the latter fungus. Numerous cases were observed in which the spores of *D. morbosum* were half surrounded by hyphal strands of *C. roseum*. Contact between *C. roseum* and hyphae or spores of *D. morbosum* was followed by disintegration of the latter.

The evidence outlined in the above paragraphs strongly indicates that *C. roseum* is an active parasite of the stroma of *D. morbosum*.

Additional Evidence

To follow the development of knots infected naturally by *C. roseum*, in August of each of two years twenty-four knots were chosen and tagged, of which eight showed severe infection, eight moderate infection and the remaining eight appeared to be free from infection by *C. roseum*. In a few cases the checks became infected subsequent to tagging and were then replaced by non-infected ones.

Periodic observations of these knots during the winter revealed essentially the same facts as did the infection experiments. In all cases perithecia developed more abundantly on non-infected knots than on knots infected by *C. roseum* during the previous summer. The majority of these naturally infected knots, subsequent to infection by *C. roseum*, showed the presence of a second fungus, namely, *Monilia* sp., which is discussed later in this article. It should also be mentioned that all check knots did not produce an abundance of perithecia. The numbers of perithecia which matured on different knots varied greatly, but the difference in their development on knots infected by, and on those free from *C. roseum*, was outstandingly apparent (Plate II, Figure 2).

A survey of the weather records for the years 1931 to 1933 inclusive indicated that mean temperatures for the two weeks in July, during which *C. roseum* consistently appeared and established itself in abundance on knots, varied from 73.2° F., in 1931 to 69.3° F., in 1933. Since this fungus is favoured by high temperatures (*4*) the prevalence of high temperature in July probably contributes to its regular appearance during that month.

Conclusions

As a result of the foregoing experiments and observations the following conclusions were reached. Each summer, beginning in July, *C. roseum* establishes itself on knots as an active parasite of the conidial-bearing stroma of *D. morbosum*. Apparently the ability of this fungus to parasitize other fungi is not restricted to *D. morbosum*. As early as 1909 Whetzel (*18*) reported *C. roseum* to be parasitic upon the fructifications of *Scleroderma vulgare*. Böning (*2*) also, in 1933, in an investigation of *Sclerotinia sclerotiorum* (Lib.) de Bary, states that "the sclerotia of this fungus are

liable to infection by *C. roseum*, which may play quite an important part in the reduction of infective material in the soil during seasons of alternating dry and wet periods."

In culture *C. roseum* appears to be definitely antagonistic to *D. morbosum*, the growth of the latter being permanently arrested, subsequent to the introduction of *C. roseum*. Furthermore, when *C. roseum* is grown in association with *D. morbosum* in Petri dish cultures the hyphae and conidia of the latter are frequently disintegrated after contact with the mycelium of *C. roseum*.

Records of the periodicity of *C. roseum* on knots outdoors would indicate that its consistent attack on *D. morbosum* in July can be attributed in part to the high temperatures which prevail at that time. One highly important practical result of the parasitism of the conidial stroma of *D. morbosum* by *C. roseum* is the consequent reduction in the number of mature perithecia developed.

CONIOTHYRIUM SPECIES ON BLACK KNOTS

During the present investigation of black knot a *Coniothyrium* sp. (probably identical with the species found by Humphrey (*8*)) has been constantly isolated from knot tissue. As Humphrey claimed this fungus to be an imperfect stage of *D. morbosum* and since the observations mentioned above seemed to corroborate this conclusion, a careful investigation of this phase was undertaken.

Isolations

Numerous isolations were made from bud and bark surfaces to find out if the *Coniothyrium* sp. was of general occurrence on the host or was confined strictly to knot tissues. Isolations from knots were made by cutting surface-sterilized plugs of tissue either from the surface or from the interior, and transferring them to tubes or Petri dishes containing potato dextrose agar.

In making isolations from branches a scalpel was scraped lightly over the surface of the branch and then dipped in a drop of sterile water on a slide. This mixture was thoroughly macerated, after which loopfuls were streaked over the surface of potato dextrose agar in Petri dishes. Examinations of these streaks were then made microscopically and single spores, chlamydospores and bits of mycelium were readily cut out and transferred to tubes.

A summary of the isolations in which *Coniothyrium* sp. was obtained during the period 1929 to 1933 is given in Table 2.

It should be pointed out that in isolations from knot swellings in their earliest visible stages *D. morbosum* alone was isolated when external tissues were removed. In all other cases, however, as will be observed from an examination of Table 2, the *Coniothyrium* sp. appeared in isolations from tissues of knots in various stages of development at all seasons of the year. It was isolated frequently not only from tissues in the swollen portion of the knot proper, but also at the edge of the knot where swollen tissues merge into those normal in size. In fact this fungus was found to be so universally present on black knots that when isolations were made from any single knot the *Coniothyrium* sp. consistently appeared in some or all of the cultures, associated with the conidial stage of *D. morbosum*.

TABLE 2.—SUMMARY OF ISOLATIONS OF *Coniothyrium* SP. FROM DIFFERENT HOST MATERIALS

Time of isolation	Materials used in isolations	Coniothyrium / Total no. of isolations
Aug. and Sept.	Tissue from incipient swellings on current season twigs. External tissues not removed.	43/57
Throughout year	Tissue from swollen areas at boundaries of knots.	274/292
Throughout year	Tissue from all parts of knot proper.	62/66
June, July and Aug.	Scrapings from conidial-bearing stroma of knot.	23/23
Jan., Feb. and March	Scrapings from perithecial-bearing stroma of knot.	35/38
April and May	Vaselined slides set up in spore traps at short distances from mature black knots.	14/200
Throughout year	Scrapings from apparently healthy plum, sour and sweet cherry, peach, pear and apple buds and branches.	52/52
Nov. to March	Monochlamydospores found on surface of twigs of *Prunus domestica* and *P. persica*.	36/275

It will be observed in Table 2 that *Coniothyrium* sp. was isolated on 36 occasions from monochlamydospores which were found on the surface of branches of *P. domestica* and *P. persica*. On 52 occasions it was isolated from the bark-surfaces of various fruit trees. No effort was made to ascertain in what form the fungus was present in these latter instances. Undoubtedly some grew from chlamydospores and some from mycelium, while others possibly developed from conidia. It should be mentioned in this connection that *Coniothyrium* sp. was not the only fungus isolated from chlamydospores and mycelium on the bark of various fruit trees. The others, however, will be dealt with in a separate article.

The fact that *Coniothyrium* sp. was isolated from the surface of apparently normal branches not only of plum but also of numerous other hosts indicates that it probably is more or less ubiquitous in nature and its habitat is not limited to black knots.

Description of Fungus

Since in the genus Coniothyrium it is almost impossible at the present time to identify species other than by their limitations to certain hosts, and because this method of identification is entirely unsatisfactory, a specific name has not been assigned to the fungus reported in this article. However, a careful description of the species as it appears on potato dextrose agar, as well as its habitats are given below.

***Coniothyrium* sp.:** Aerial mycelium of young colonies white, sometimes turning to a decidedly pink colour, and later turning brown commencing in the central

portions. The brown mycelium appears in some cases in radial bands and in others diffuses regularly from the centre of the colony (Plate I, Figure 3). Later, pycnidia develop, appearing first in older parts of the colony. Colonies attain a diameter of approximately 40 mm. in seven days in Petri dish cultures incubated at 68–70° F. Pycnidia spherical to compressed with definite, circular ostioles, dark brown, usually superficial on substratum, single or more frequently gregarious, walls membranaceous, in old cultures frequently exuding gelatinous spore masses, the shiny surfaces of which impart to the colony a somewhat mottled appearance, 150–515 μ in diameter (not including the somewhat extended ostioles); spores in mass inky black, seen singly darkly olivaceous, mostly ovoid but varying from short cylindric to pyriform, irregularly guttulate 3.84–7.6 × 2.8–3.8 μ. Habitat: Isolated consistently from all but very young black knots, also from the buds and bark of *Prunus domestica*, *P. virginiana*, *P. pennsylvanica* and *P. cerasus*, *Pyrus malus* and *P. communis*.

Chlamydospore Formation

Following the discovery that a proportion of the cultures of monochlamydosporous origin were the *Coniothyrium* sp. which was consistently isolated from knots, a cultural investigation was undertaken to find out if the life cycle included such a stage. The fungus was grown on various media under different conditions of temperature and moisture. In all cases only pycnidia and pycnospores of *Coniothyrium* sp. developed. When, however, a bacterial organism also isolated from the surface of the bark antagonistic to *Coniothyrium* sp. was introduced into a Petri dish culture at some distance from the latter, chlamydospores developed in the mycelium nearest the bacteria (Plate II, Figure 7). This confirmed the evidence obtained from the isolations and indicated that the production of chlamydospores may frequently be a normal stage in the life cycle of this organism.

Evidence of Two Strains of *Coniothyrium* sp.

During the course of this phase of investigations the occurrence of two morphologically distinct strains of Coniothyrium was established. These two strains, tentatively designated A and B, were isolated at different times from knots on various hosts and no particular limitations regarding their occurrence was observed except that strain A was isolated much more frequently from *P. domestica* than was strain B. On potato dextrose agar strain A may be distinguished from strain B by its slightly more rapid growth, by a later and usually less abundant development of pycnidia as well as by the dark brown mycelium radiating from the centre of the colony (Plate I, Figure 3). Besides, strain B is usually somewhat more pink in culture than strain A.

The Association of *Coniothyrium* sp. with *D. morbosum* in Culture

The *Coniothyrium* sp. and the conidial stage of *D. morbosum* were grown together on potato dextrose agar to note the effect (if any) of the one fungus on the other. Up to the point of meeting of the two fungi apparently no inhibitory effect was exerted by one organism on the other. However, following contact of the organisms, *D. morbosum* showed no further development and almost invariably was encroached upon by the *Coniothyrium* sp. On the portion of the colony of *D. morbosum* overrun by the *Coniothyrium* sp. an abundance of pycnidia of the latter organism frequently developed.

Authentic evidence of the parasitism of *D. morbosum* by the *Coniothyrium* sp. was not obtained in culture.

PLATE I

FIGURE 1. The extreme case of callus formation on artificially-injured check branch of *P. cerasus*.

FIGURE 2. Branch of *P. cerasus* three months after inoculation with *Coniothyrium* sp. Note swollen area around point of inoculation.

FIGURE 3. Colonies of *Coniothyrium* sp., upper, strain A, lower, strain B.

FIGURE 4. Drawing of longitudinal section of perithecium of *D. morbosum* illustrating the production of pycnidia by the *Coniothyrium* sp. within the perithecia of the former fungus.

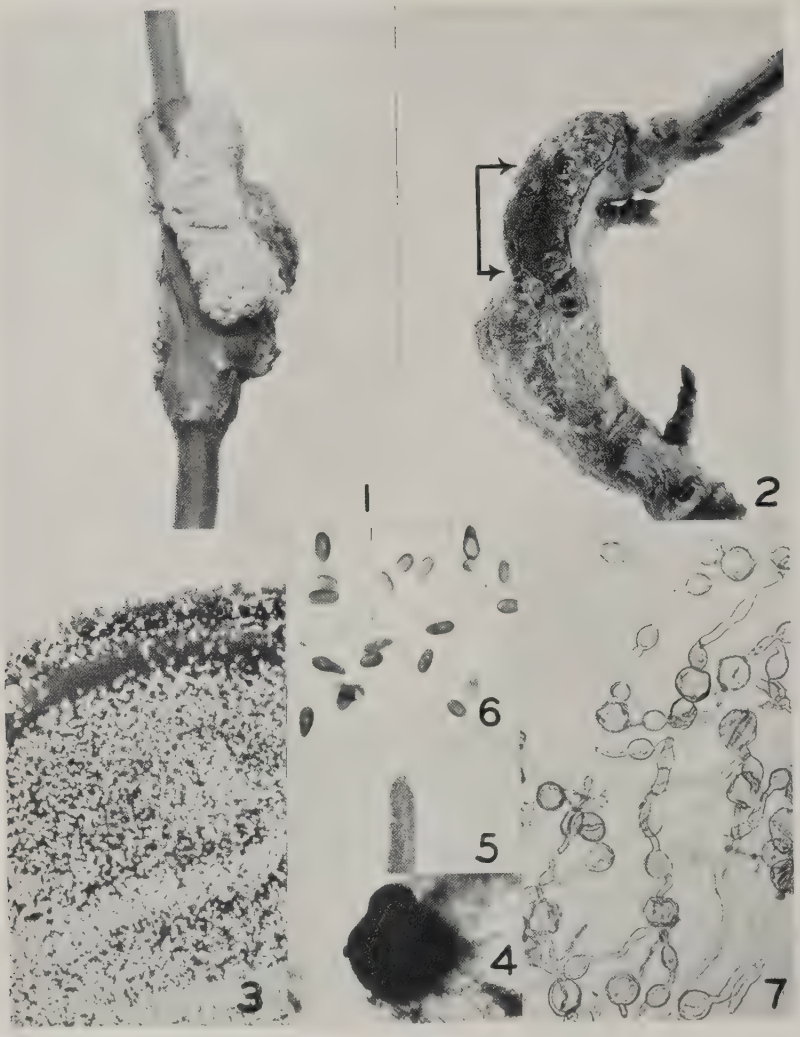

PLATE II

FIGURE 1. *C. roseum* parasitizing the conidial fructification of *D. morbosum* in July.

FIGURE 2. Appearance of a knot in April parasitized previous summer by *C. roseum* except in region indicated by arrows. Note presence of perithecia in non-parasitized region only.

FIGURE 3. Photograph showing *C. roseum* growing on surface of conidial stage of *D. morbosum* in Petri dish culture.

FIGURE 4. Pycnidium of *Coniothyrium* sp. × 55.

FIGURE 5. Photomicrograph of tip of "spore tendril" recently exuded from pycnidium of *Coniothyrium* sp. × 450.

FIGURE 6. Photomicrograph of pycnospores of *Coniothyrium* sp. × 710.

FIGURE 7. Photomicrograph of chlamydospores of *Coniothyrium* sp. × 450.

Evidence Obtained from Sections of Black Knots

To obtain more complete information concerning the habits of the *Coniothyrium* sp. in its relation to black knot, sections were made of knots in various stages on *Prunus domestica*, *P. virginiana* and *P. pennsylvanica*. Sections were obtained with the use of a sliding microtome and were usually stained in cotton blue. Examinations of these sections showed that very soon after the external tissues of young knots became broken, mycelium appeared in these tissues, quite different in character from that of *D. morbosum*, which is easily recognized by its characteristic phalangial aggregates of hyphae. Examinations of numerous other sections showed that pycnidia of the *Coniothyrium* sp. were present on knots at any time after the first appearance of conidia of *D. morbosum* in the summer and even after the perithecia were fully mature. Pycnidia could be found anywhere within the fruiting area of the knot and were frequently half-imbedded among the conidiophores and conidia. During the fall and winter pycnidia of Coniothyrium were abundant on the perithecial stroma of *D. morbosum* on *P. pennsylvanica* in particular, and mycelium frequently penetrated the immature perithecia. In more advanced stages mature pycnidia of *Coniothyrium* were observed actually within almost empty perithecia from the mouths of which their ostioles protruded (Plate I, Figure 4).

Infection Experiments

Numerous infection experiments involving *Coniothyrium* sp. were conducted during a period of four years. Many inoculations were made on healthy branches of *P. domestica* and *P. cerasus*, primarily to discover whether this organism alone was capable of inducing the formation of knots. During the past two years numerous knots were also inoculated in the hope of obtaining more information concerning the habits of the *Coniothyrium* sp. In all inoculations a water suspension of pycnospores belonging to either one or both strains was applied either with an atomizer or a camel's hair brush. Twigs and branches were surface-sterilized with mercuric chloride and washed with sterile water before inoculating. Checks were made for all infection experiments except those involving knots in which case ordinary knots had to be used. Since space does not permit a complete description of all infection experiments carried out with this organism a small number of representative experiments and the results obtained are summarized below in Table 3.

In the first place, from Table 3, it is readily seen that in no instance did typical black knots develop as a result of inoculation with *Coniothyrium* sp. When branches of *P. domestica* and *P. cerasus* were injured and inoculated, however, they did develop swollen areas around the points of inoculation during the current season of growth (Plate I, Figure 2). Pycnidia finally developed within the crevices of the swollen areas on inoculated branches. Checks, on the other hand, which were made under precisely identical conditions did not manifest similar swellings. On branches of the above-mentioned hosts which were uninjured but inoculated, no swellings developed except very small ones where tiny twigs were pruned. It will also be observed that brown, somewhat elevated lesions, variable in size, developed on current season twigs which were inoculated and covered for two weeks with cellophane bags. It should be mentioned, however, that current season twigs inoculated in a manner

TABLE 3.—INFECTION EXPERIMENTS WITH *Coniothyrium* SP. ON BRANCHES OF *P. domestica*

Date of experiment	No. of inoculations	Host	Treatment	Results
12.5.31	8	Branches several years old, *P. domestica.*	Injured to xylem with scalpel and bound for two weeks with moist blotting paper enclosed with wax paper.	Three months later all branches somewhat swollen in vicinity of inoculations. Pycnidia of *Coniothyrium* sp. in crevices.
12.5.31	8	Branches several years old, *P. domestica.*	Uninjured except for pruning of tiny twigs. Bound for two weeks with moist blotting paper enclosed with wax paper.	Three months later all inoculated branches were not affected except for tiny swellings which appeared around some pruning wounds. Pycnidia in crevices of bark.
12.5.31	8	Checks	Checks (Injured)	Three months later all checks calloused but not swollen.
20.5.32	4	Current season twigs Reine Claude plums.	Spores atomized on twigs and twigs covered with cellophane bags for two weeks.	Two months later numerous brown lesions several mms. in diameter appeared on twigs.
20.5.32	4	Checks	Checks	Two months later all checks showed no change.

similar to that described above except that they were not covered with bags developed no, or relatively few, brown lesions which were smaller in size, usually 1 or 2 mm. in diameter.

A noteworthy feature of the inoculations which developed swollen areas was the fact that the swellings did not continue to increase in size subsequent to the year in which they were made. After three, and in some cases, four years, these swollen areas are still noticeable but are evident more by their character than their size. Areas in the vicinity of the swellings are darker in colour than surrounding bark and creviced longitudinally. After three years pycnidia of *Coniothyrium* sp. are still present within the crevices. Reisolations have been made at intervals from many of these inoculations and they seldom failed to yield *Coniothyrium* sp. The fact that no swellings developed on uninjured branches which were inoculated with *Coniothyrium* sp. would indicate that the fungus was unable to penetrate the periderm layers covering the inner host tissues. When inoculations were made on current season twigs later than May the brown lesions referred to above did not develop, though the fungus was frequently reisolated several months later from these twigs. Examinations of twigs on which the brown lesions developed revealed mycelium within the boundaries of the lesions between the cuticle and the epidermis. Later in the fall these lesions were apparently cut off by a layer of periderm which formed beneath the lesions. During the winter they gradually lost

their individuality and though the fungus was still present their locations were marked only by the absence of cuticle on the infected areas.

With reference to the experiments in which knots were inoculated with *Coniothyrium* sp. inconsistent results were obtained. The chief difficulty encountered here was the impossibility of finding knots entirely free from this fungus and, therefore, of making comparisons. They did, however, confirm one point of evidence previously obtained from the study of sections of knots, namely, that during the latter part of the life cycle of knots *Coniothyrium* sp. becomes parasitic on the stroma of *D. morbosum*. More abundant pycnidia were present on inoculated than on non-inoculated ones, and occasionally distinct evidence of parasitism was apparent.

The above experiments and observations prove that this *Coniothyrium* sp. hitherto reported to be the pycnidial stage of *D. morbosum* and found closely associated with all except the most incipient stages of black knots, does not belong genetically to *D. morbosum*. The following reasons are submitted for arriving at the above conclusion:

1. Cultures from ascospores and conidia of *D. morbosum* never yielded *Coniothyrium* sp.
2. Cultures from internal tissues of young knots when they were first visible as minute swellings on current season twigs did not yield *Coniothyrium* sp. although they did yield the conidial stage of *D. morbosum*.
3. Cultures of *Coniothyrium* sp. always produced pycnidia and pycnospores, and never conidia or perithecia of *D. morbosum*.
4. *Coniothyrium* sp. was isolated not only from knots but also from various other parts of *P. domestica* and other hosts.
5. Inoculations of twigs of *P. domestica* with pycnospores of *Coniothyrium* sp. gave positive infection but did not result in the development of typical black knots in contrast to similar inoculations with *D. morbosum*.

In summarizing the results of the observations and experiments on *Coniothyrium* sp. and its relation to black knot the following conclusions have been reached.

Coniothyrium sp. becomes associated with black knots very early in their development, probably as soon as the knot becomes visible to the eye as a small swelling on a current season twig. At this stage the cuticle of the host is broken and frequently the epidermis as well, making an admirable resting place for any fungus. Not until this time do the two fungi become intimately associated. Subsequent to this developmental stage apparently all knots during part or all of the remainder of their life cycles have *Coniothyrium* sp. associated with them. It is probable that the mycelium which has been observed to be distinct from that of *D. morbosum* in sections of young knots belongs to *Coniothyrium* sp. since this fungus is the only one which has been consistently isolated along with *D. morbosum* at this stage.

At all times subsequent to the production of conidia by the knot the pycnidia of *Coniothyrium* sp. have been observed situated either superficially or among the conidiophores of *D. morbosum*. Numerous sections of knots in all stages of development have indicated that actual parasitism

of the stroma of *D. morbosum* by the *Coniothyrium* sp. does not take place until towards the following spring when the perithecia are maturing. Occasionally immature perithecia appear to be invaded by the fungus and frequently a degeneration of the contents is followed by the formation of pycnidia of the *Coniothyrium* sp. within the walls of the perithecia.

MONILIA SP. ON BLACK KNOTS

For the past three years a fungus producing a white mat of mycelium has been observed on knots which were first attacked by *Cephalothecium roseum*. Occasionally the fungus also appeared on knots which appeared to be free from *C. roseum*. Many unsuccessful attempts were made to determine the identity of the fungus as it appeared on the host. In pure culture, however, it proved to be a species of Monilia and it has been isolated on numerous occasions since September 1931 from *Prunus domestica*, *P. pennsylvanica* and *P. virginiana*. Since this fungus did not appear to play a particularly significant rôle in relation to black knot its action was not investigated in detail. When the *Monilia* sp. was grown in Petri dish cultures in association with *D. morbosum* each exhibited a tolerance towards the other. Under such circumstances the *Monilia* sp. ultimately covered the dark mat of conidiophores and conidia of *D. morbosum* with its loose, cottony, white mycelium and produced an abundance of conidial chains superficially.

Because of its frequent occurrence on knots in the summer, and judging by its cultural reactions referred to above, it may be considered with a measure of justification to be sometimes parasitic on the stroma of *D. morbosum*.

HENDERSONULA MORBOSA SACC. ON BLACK KNOTS

This fungus was discovered first on the stromata of black knots by Farlow (*5*) in 1896. He interpreted it as a pycnidial stage of the organism causing black knot.

H. morbosa was first isolated during the present investigations on May 29, 1930, from a perithecial maceration of a knot on *Prunus cerasus* collected in the Georgian Bay district. Since that date it has been isolated on numerous occasions from knots on both *P. domestica* and *P. cerasus* collected in the above-mentioned district.

Close examinations of these knots showed that acervuli of *H. morbosa* were situated among the perithecia of *D. morbosum*. Cultures of *H. morbosa* were obtained only from conidia of the same fungus and never from ascospores of *D. morbosum*.

Branches of both *P. domestica* and *P. cerasus* were inoculated with *H. morbosa* in a manner similar to that used with *Coniothyrium* sp. (see infection experiments). In no instance did knots develop. However, a specific reaction was manifested by all inoculated branches in the form of a copious exudate of gum around each point of inoculation. Checks, on the other hand, never exhibited this reaction.

After it had been demonstrated that *H. morbosa* was not genetically connected with *D. morbosum* and that it was incapable of producing black knots, further investigations of this fungus were abandoned. The observations and examinations of knots on which *H. morbosa* was present would,

however, indicate its ability to act as a parasite on the stroma of *D. morbosum*.

SPHAERONEMA SP. ON BLACK KNOTS

Incidental to the present investigations, examinations of knots kindly supplied by H. T. Güssow, Dominion Botanist, revealed pycnidia of a member of the Fungi Imperfecti on the perithecial-bearing stroma of *D. morbosum*. The fungus was identified as a species of Sphaeronema.

Dr. Güssow first collected knots on which this fungus was present in 1909 near St. Johns, Newfoundland, on *Prunus pennsylvanica*. Since that time he has collected similar specimens in the same area as well as at Norway

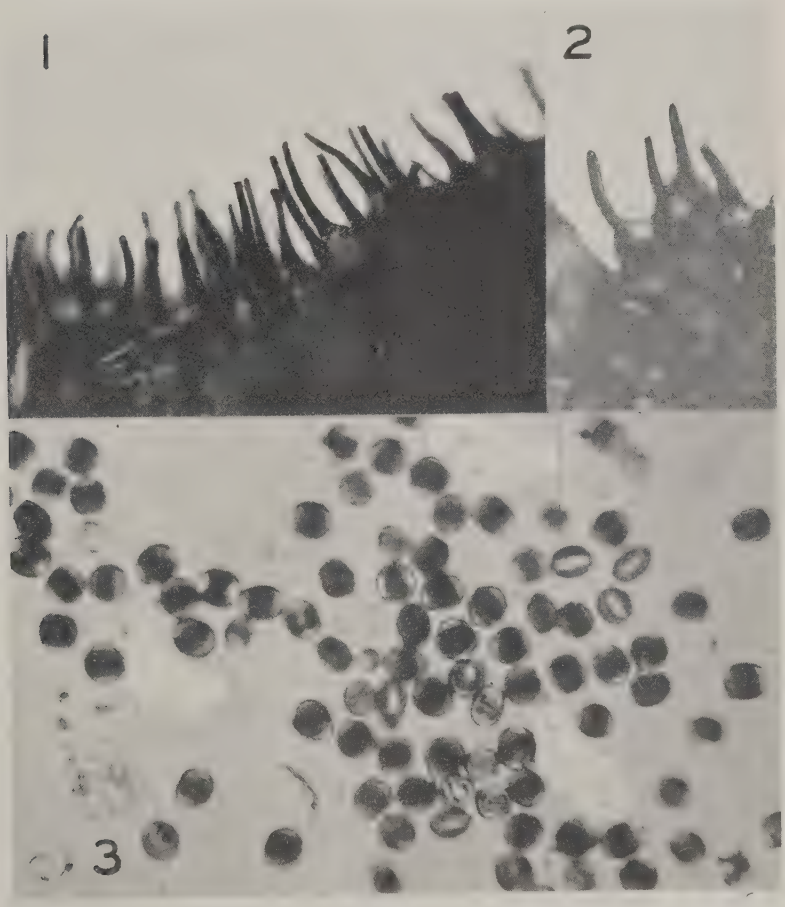

PLATE III

FIGURES 1 and 2. *Sphaeronema* sp. fruiting on stroma of *D. morbosum*. × 40. Note long necks on pycnidia.

FIGURE 3. Pycnospores of *Sphaeronema* sp. × 650.

Bay, Ontario, on the same host. F. L. Drayton has observed the same fungus on knots on *P. domestica* collected in the Adirondack Mountains.

On the specimens examined, the pycnidia of the *Sphaeronema* sp. were present in great abundance both superficially and among the perithecia of *D. morbosum* to the extent that in some cases they entirely replaced the perithecial-bearing stroma of the latter fungus (Plate III). In these instances parasitism of the stroma of *D. morbosum* by the *Sphaeronema* sp. was indicated, but since no cultures of the latter species were obtained and since no specimens of a similar nature were observed in the Niagara Peninsula, a definite statement cannot be made in this connection.

OTHER FUNGI ISOLATED FROM KNOTS

Other fungi such as *Fusarium* sp., *Alternaria* sp., *Nectria* sp., *Sporotrichum* sp., *Phoma* sp., *Cladosporium* spp. and a Torula-like fungus were frequently isolated from knot stromata, in particular from those bearing conidiophores and conidia. Some or all of these fungi may possibly be consistently parasitic on the stroma of *D. morbosum*. The investigation of this phase was not sufficiently intensive, however, to determine the importance of any other than the more common associates.

DISCUSSION

The outstanding feature of the above investigation on black knot is the demonstration of a measure of biologic control exerted by *C. roseum* in reducing materially the number of perithecia of *D. morbosum* which develop on any mature knot. The degree of importance which should be attached to this type of control in a consideration of black knot is difficult to evaluate. In many other diseases where a similar phenomenon has been proved it is considered to be relatively unimportant from the practical standpoint. On the other hand the importance of *C. roseum* in the black knot disease was observed in the laboratory plum orchard in a block of check trees which were neither sprayed nor pruned during the past five years.

During the first four years the number of knots occurring on these trees increased quite regularly and during the first three years at least, an abundance of perithecial material was available in the spring. During the same period knot infection by *C. roseum* was increasing in direct proportion to the increase in the number of knots until finally practically 100% of the knots were infected by this fungus. During the past year a sharp drop in the number of new knots was noted and the amount of available, mature, perithecial material decreased to the point where to obtain the perfect stage it was necessary to go to other parts of the orchard where there were fewer knots and where infection by *C. roseum* was not so general. This circumstantial evidence substantially confirms that already submitted to the effect that *C. roseum* does cause an important measure of biologic control of black knot.

Another feature of the present investigation of black knot is the observation that a *Coniothyrium* sp., though itself incapable of producing typical black knots, is always found associated with *D. morbosum* in all knots except those in their most incipient stages. It is true that on branches of *P. domestica* which were artificially injured and inoculated with the *Coniothyrium* sp. a certain amount of swelling was induced during the

current season of growth. However, these swollen areas did not continue to increase in size in subsequent years nor did swellings develop on branches of the same host where no infection courts were provided. In addition to its constant association with black knots this fungus has proved to be more or less ubiquitous, having also been found superficially on the bark and buds of many fruit trees.

The above points of evidence would seem to warrant the conclusion that this *Coniothyrium* sp. does not play a limiting rôle in the development of knots. Its universal presence on all except very young knots, as well as the results outlined in the present investigation lead to the conclusion that black knots merely furnish an unusually favourable substratum for this fungus. During the later developmental stages of knots the *Coniothyrium* sp. has been observed to be definitely parasitic on the stroma produced by *D. morbosum*. Therefore, though it must not be referred to in a consideration of the *cause* of the disease, *Coniothyrium* sp. must receive consideration in connection with the normal development and sequence of events which transpire during the life cycle of a knot.

In concluding it is postulated to be a normal occurrence for all black knots to become parasitized at some time in their life cycles by *Coniothyrium* sp. Besides, many are also parasitized by *C. roseum* and other fungi. On the other hand, it must be considered highly extraordinary if one or more of the fungi enumerated in this article are not present on any knot far enough advanced to produce conidia.

While the scope of the investigations of fungi which are parasitic on *D. morbosum*, outlined in this article has been fairly comprehensive it is by no means exhaustive and further studies would probably throw additional light on the phenomenon of infection of black knots by other organisms.

ACKNOWLEDGMENT

Thanks are gratefully extended to Dr. G. H. Berkeley for helpful suggestions at various times in the course of investigation.

SUMMARY

1. *Cephalothecium roseum* Corda appears consistently in July and August every year on the conidial-bearing stroma of *Dibotryon morbosum* (Sch.) T. & S., in many knots on various hosts.

2. Evidence is adduced that in nature *C. roseum* actively parasitizes the stroma of the black knot organism.

3. When *C. roseum* is introduced into a Petri dish culture at some distance from a young colony of *D. morbosum* the growth of the latter is after a few days permanently arrested. *C. roseum*, on the other hand, grows rapidly over the medium and finally parasitizes the colony of *D. morbosum* inducing a disintegration of its mycelium.

4. Observations and infection experiments have indicated that *C. roseum* exerts an important measure of natural biologic control over *D. morbosum*. This is brought about by a destruction of the perithecial initials in the conidial-bearing stroma and is manifested usually by a reduction in numbers, and occasionally by a complete inhibition of perithecia on infected knots.

5. Over a period of four years a species of *Coniothyrium* has been isolated at will from all knots except those in their earliest stages of development. This *Coniothyrium* sp. has also been isolated at all times of the year from the bark and buds of apparently healthy branches of *Prunus domestica*, *P. cerasus*, *P. virginiana*, *P. pennsylvanica* and *P. persica*, *Pyrus communis* and *P. malus*. Its presence during the winter in the form of chlamydospores on the bark of the above-mentioned hosts has been demonstrated.

6. A description of the *Coniothyrium* sp. is given.

7. The *Coniothyrium* sp. and *D. morbosum* manifested a mutual tolerance toward each other when grown as associates in culture.

8. Infection experiments have demonstrated that this *Coniothyrium* sp. is capable of causing slight swellings but not typical knots, on branches of *Prunus domestica* and *P. cerasus* when infection courts are provided.

9. Evidence is submitted which proves that the *Coniothyrium* sp. is not genetically connected with *D. morbosum*.

10. During the later developmental stages of knots, the *Coniothyrium* sp. has been observed to produce an abundance of pycnidia around and within both immature and mature perithecia of *D. morbosum*.

11. A species of Monilia, *Hendersonula morbosa* Sacc., *Sphaeronema* sp., *Nectria* sp., *Phoma* sp., *Sporotrichum* sp., *Cladosporium* spp., *Fusarium* sp., *Alternaria* sp., and a Torula-like fungus were frequently isolated from black knots. None of these fungi is an imperfect stage of *D. morbosum*.

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Résumé

Recherches sur le Black Knot des pruniers et des cerisiers, II. Manifestation et signification de certains champignons trouvés en association avec le *Dibotryon morbosum* (Sch.) T. et S. L. W. Koch, Pathologiste-adjoint en végétaux, Laboratoire fédéral de pathologie végétale, St. Catharines, Ontario.

Le *Cephalothecium roseum* Corda fait son apparition régulièrement en juillet et en août tous les ans sur les stromas conidiophores de *Dibotryon morbosum* (Sch.) T. & S., dans bien des noeuds sur différents hôtes. Il a été démontré que dans les conditions naturelles le *C. roseum* vit en parasite sur le stroma de l'organisme du noeud noir (Black Knot). Lorsqu'on introduit le *C. roseum* dans une culture sur plat Petri, à quelque distance d'une jeune colonie de *D. morbosum*, la végétation de cette dernière est permanemment interrompue au bout de quelques jours tandis que, le *C. roseum* se développe rapidement sur le milieu et envahit finalement la colonie de *D. morbosum*, provoquant une désagrégation de son mycélium. Les observations et les essais d'infection ont indiqué que *C. roseum* exerce un contrôle biologique naturel important sur le *D. morbosum*. Ce contrôle est provoqué par une destruction des périthèces naissants dans le stroma conidiophore et il se manifeste ordinairement par une réduction du nombre et parfois par une suppression complète des périthèces sur les noeuds infectés. Pendant une période de quatre ans, une espèce de *Coniothyrium* a été isolée facilement de tous les noeuds sauf ceux qui étaient dans leurs premières phases de développement. Cette espèce de *Coniothyrium* a été isolée également, à tout moment de l'année, de l'écorce et des bourgeons de branches apparemment saines de *Prunus domestica*, *P. cerasus*, *P. virginiana*, *P. pennsylvanica* et *P. persica*, *Pyrus communis* et *P. malus*. Sa présence en hiver sous forme de chlamydospores sur l'écorce des hôtes précités a été démontrée. Une description de l'espèce *Coniothyrium* est donnée. Les espèces *Coniothyrium* et *D. morbosum* ont manifesté une tolérance mutuelle l'une envers l'autre lorsqu'elles étaient cultivées ensemble. Les essais d'infection ont démontré que cette espèce *Coniothyrium* peut causer de légères boursouflures, mais non pas de noeuds typiques, sur les branches de *Prunus domestica* et *P. cerasus* lorsque des foyers d'infection sont pourvus. Des preuves sont soumises démontrant que l'espèce *Coniothyrium* n'a pas de parenté génétique avec le *D. morbosum*. Pendant les dernières phases du développement des noeuds, on a constaté que l'espèce *Coniothyrium* produit une abondance de pycnidies autour et en dedans des périthèces non mûrs et mûrs de *D. morbosum*. On a souvent isolé des noeuds noirs des espèces de Monilia, *Hendersonula morbosa* Sacc., *Sphaeronuma*, *Nectria*, *Phoma*, *Sporotrichum*, *Cladosporium*, *Fusarium*, *Alternaria* et un champignon semblable au Torula. Aucun de ces champignons n'est une phase imparfaite de *D. morbosum*.

ZONATION FOR FERTILIZER REQUIREMENTS IN THE NORTHERN PRAIRIES

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INTRODUCTION

A series of fertilizer trials[2] covering the grain producing portion of Manitoba was undertaken during the years 1929, 1930 and 1931, the results of which suggest a zoning for fertilizer requirement of cereals when the drilling-in method is used in the Canadian prairies.

The superiority of the drilling-in method of application and its use in other countries is shown by Richardson (*5*), Dudley (*2*), Truog (*7*), Salter (*6*) and others.

The practice of drilling in fertilizer with the seed, which has proved to be one of the most important contributions to cereal production in Western Canada, was introduced into the West in 1928. Prior to 1928 and at various intervals during the development of the Canadian West, experiments were conducted with the application of commercial fertilizers to cereals and other crops by the broadcast method. The results obtained in general did not indicate sufficient response to cause any considerable extension of these trials, or to warrant the recommendation of fertilizers for general use, until the Australian type of combined grain and fertilizer drill was introduced for experimental use in 1928. The subsequent trials with phosphate fertilizers opened up a new aspect in the fertilization of cereals on the Canadian prairies.

FERTILIZER PROJECT

In 1929 a simple series of fertilizer trials was undertaken in Manitoba by the Junior Co-operators and continued for a three-year period. The trials, which were distributed throughout the grain producing area of the province, were conducted at 130 points in 1929, at 122 points in 1930, and at 70 points in 1931. On each farm duplicate plots of Reward wheat were planted in replicated rod-rows, each one foot apart and with an untreated guard row between each treatment. The fertilizer was applied in drills by hand one inch below the seed at the time of seeding. The treatments included: (*1*) ammoniacal nitrogen; (*2*) nitrate nitrogen; (*3*) phosphate; (*4*) potash; (*5*) ammonia and phosphate; (*6*) ammonia and potash; (*7*) phosphate and potash; (*8*) ammonia, phosphate and potash; (*9*) no fertilizer. The amounts of fertilizer applied were as shown in the accompanying table.

At each point, four replicated rows of each of the nine treatments were harvested. The 36 separate rows were shipped to the University, where they were threshed and the yields and errors for each point were

[1] Soils Division, Department of Agronomy.

[2] The fertilizer trials here reported were conducted by the "Junior Co-operators" and financed by the Educational Department of the Manitoba Wheat Pool co-operating with the Soils Division, Manitoba Agricultural College. The writer herewith expresses to the Junior Co-operators his sincere appreciation of the faithful manner in which they carried out their assignments, and especially desires to acknowledge the kindly interest displayed throughout by Mr. C. H. Burnell, President of the Manitoba Wheat Pool, whose energetic co-operation made the project possible. Grateful acknowledgment is also made of the assistance and advice given by Dr. C. H. Goulden in connection with the statistical treatment of the data.

AMOUNTS OF FERTILIZER APPLIED*

Kind of fertilizer	Rate per acre in pounds	Pounds of fertilizer ingredients per acre		
		N	P_2O_5	K_2O
Ammonium Sulphate	112½	22½	—	—
Sodium Nitrate	150	22½	—	—
Triple Superphosphate	75	—	33	—
Sulphate of Potash	50	—	—	24
Ammonium Sulphate and Triple Superphosphate	112½ and 75 = 187½	22½	33	—
Ammonium Sulphate and Potassium Sulphate	112½ and 50 = 162½	22½	—	24
Triple Superphosphate and Potassium Sulphate	75 and 50 = 125	—	33	24
Ammonium Sulphate, Triple Superphosphate and Potassium Sulphate	112½ and 75 and 50 = 237½	22½	33	24

*The amounts of fertilizer given per acre were the amounts actually used on an acre basis with the drill rows one foot apart.

calculated; all the records from farms having excessively high standard deviations were discarded. The average annual yield for each of the fertilizer treatments on the individual farms was compiled and treated as single replicates or blocks in the yield tables for each of the nine agricultural districts in which the trials were distributed (Figure 1). The records for each of the three years were submitted to an analysis of the variance by Fisher's method (*3*).

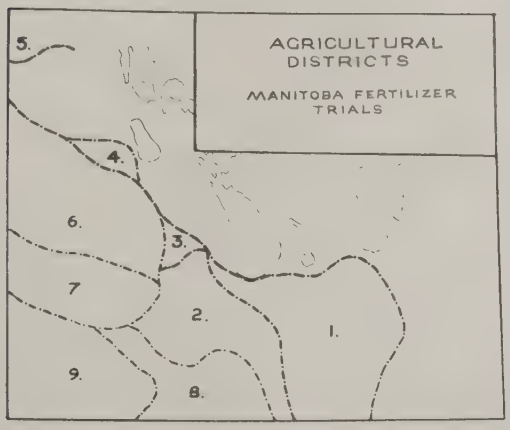

FIGURE 1. Agricultural districts of Manitoba in which fertilizer trials were conducted 1929-1930-1931.

On account of ammonium sulphate being used as the carrier of nitrogen where required in combination, the yields for nitrogen alone in the variance tables were taken from the ammonium sulphate treatments. The nitrate treatments are reported separately.

RESULTS

The results obtained for each of the nine districts are presented in Tables 1 to 3, which show the following by years: Table 1, the average yields of grain in bushels per acre; Table 2, the analysis of variance of the data for each year; and Table 3, the summary of the effect of each element on the yield in bushels per acre.

A graphic representation of the mean yields for the three years in per cent of the general mean of each district, which are tabulated in Table 1, is presented in Figure 2. The graphs in this figure present the yields in

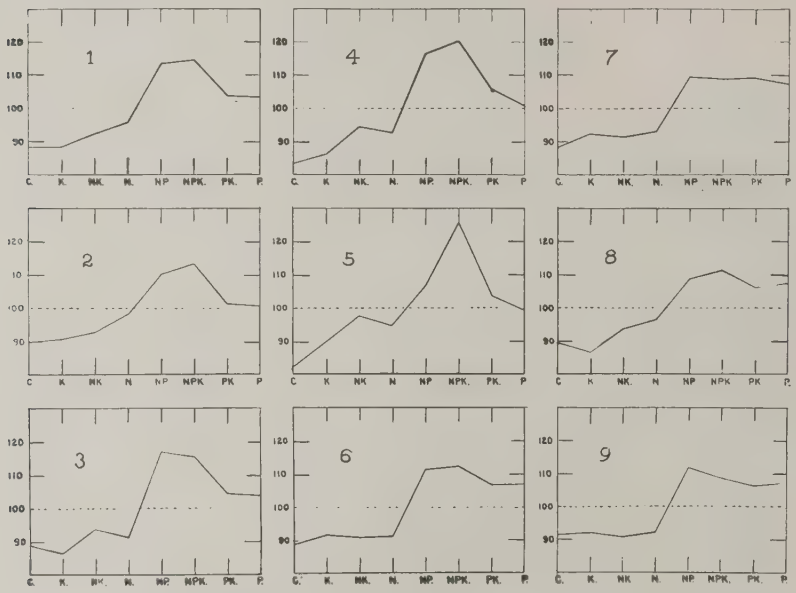

FIGURE 2. Average yields of wheat in percent of each district mean. The large numbers refer to crop districts and the symbols across the base of each graph are in the order of C. K. NK. N. NP. NPK. PK. P. from left to right.

per cent of the general mean for each of the treatments in each district in the order of: (*1*) check, (*2*) potash, (*3*) nitrogen and potash, (*4*) nitrogen, (*5*) nitrogen and phosphate, (*6*) nitrogen, phosphate and potash, (*7*) phosphate and potash, and (*8*) phosphate, and arranged from left to right so that the phosphate treatments are shown at the right of each graph. The curves shown in Figure 2 for each of the nine districts may be classified into three types:

(1) Those showing response to phosphate only;

(2) Those showing response to nitrogen and phosphate, and

(3) Those showing response to nitrogen, phosphate and potash.

By arranging the graphs on the map according to districts, a geographical distribution of the three types of curves is apparent (Figure 3). This distribution is definite and specific and is shown in summary form in Table 4. In this summary the average increase or decrease with nitrogen, phosphate and potash was calculated by combining all treatments with and without each fertilizing element by districts. The mean figures are arranged in the table in the order of the geographical occurrence of each district, (A) from south to north, and (B) from east to west.

The figures of the percentage increase in Table 4 (A) show that districts 1, 2 and 3 may be grouped on the basis of similar response. These

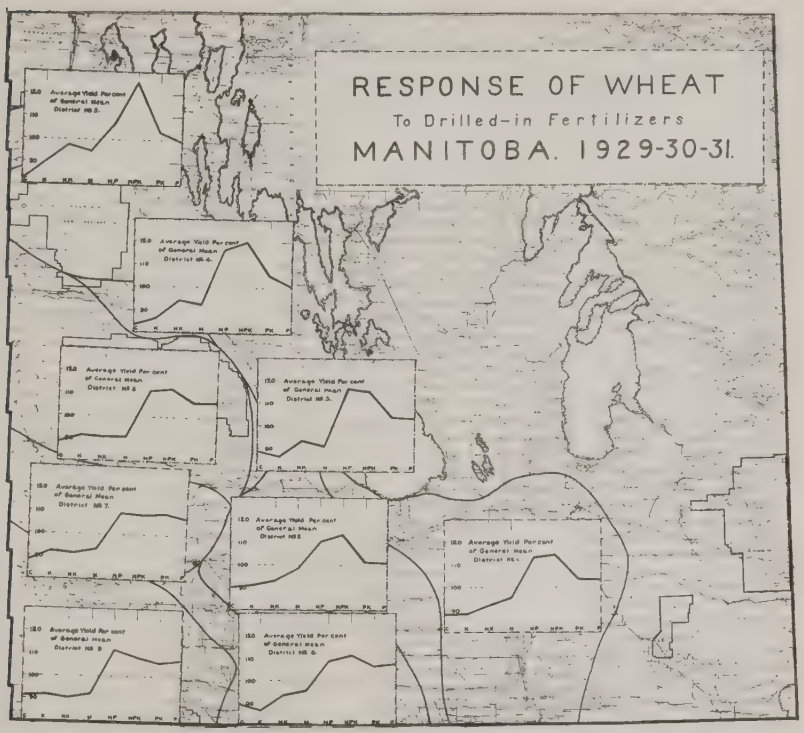

FIGURE 3. Yield-curve charts superimposed over Agricultural district map to show geographical distribution of response. The symbols across the base of each graph are in the order of C. K. NK. N. NP. NPK. PK. P. from left to right.

show significant and marked increase with phosphate, and significant though smaller increase with nitrogen. In the more northerly districts (4 and 5) similar response was obtained with phosphate, but increasing response was secured with nitrogen. In these two districts a tendency to increased yield with the use of potash appears. This increase is slight and barely significant in district 4. In district 5, individual farm records showed significant response to potash especially in 1930, but the limited number of trials in this district and the differential response to potash on different farms resulted in a relatively high standard error. Hence the significance of the average results for the district is lowered. From east to west the percentage figures in Table (B) show a similar response to phosphate throughout, and with no response to potash. The response to nitrogen however, which is significant in the eastern districts (1, 2 and 3) is not apparent in the Western districts (7, 8 and 9).

The analyses of variance given in Table 2 do not show significant interactions of the first order between nitrogen and phosphate, nitrogen and potash, or phosphate and potash. Neither is there any apparent second order interaction with the combination of the three elements. On

TABLE 1.—MEAN YIELDS OF GRAIN IN BUSHELS PER ACRE

District	Year	No. of farms	Fertilizer treatment								General mean	Standard error
			None	N.	P.	K.	NP.	NK.	PK.	NPK.		
No. 1. Red River Valley	1929	10	22.9	24.4	27.3	22.9	29.4	24.1	27.1	29.4	25.94	0.718
	1930	11	20.8	23.3	23.5	21.4	26.3	22.2	23.3	26.9	23.46	0.750
	1931	10	19.1	20.6	22.9	18.6	25.2	19.5	23.6	25.3	21.85	0.687
No. 2.—Assiniboine Delta	1929	9	21.4	25.2	26.2	23.0	30.2	22.4	26.7	29.6	25.59	1.01
	1930	11	21.7	24.6	22.9	21.3	26.5	24.3	23.4	28.2	24.11	0.913
	1931	8	13.3	13.0	14.5	13.1	14.2	12.5	14.2	14.9	13.71	0.650
No. 3.*—Riding Mountain Wash	1929	3	20.4	18.9	24.0	19.4	27.4	19.3	25.3	27.4	22.76	1.196
	1930	3	20.9	23.5	24.2	20.8	26.8	24.3	23.0	26.2	23.71	1.002
No. 4.—Dauphin Area	1929	4	15.0	15.8	19.0	14.2	22.4	15.3	19.8	22.9	18.05	0.826
	1930	3	19.0	22.1	24.2	19.8	27.3	20.7	24.8	29.4	23.41	1.091
	1931	2	22.5	25.2	24.6	25.0	28.6	28.9	26.7	28.5	26.25	0.904
No. 5.—Swan River Valley	1929	5	27.2	27.5	29.5	26.2	31.7	27.4	28.9	33.5	28.99	1.093
	1930	3	12.3	18.2	15.2	15.9	17.9	18.5	18.0	25.7	17.71	3.200
	1931	4	25.8	26.7	34.0	27.7	33.9	29.0	33.8	35.9	30.85	2.340
No. 6.—Northern Drift	1929	15	24.1	23.2	27.7	23.2	29.6	24.7	28.4	30.7	26.45	0.734
	1930	16	20.3	22.8	24.0	21.2	25.3	22.1	24.1	26.0	23.22	0.659
	1931	14	18.1	18.1	23.3	19.8	23.5	17.4	22.6	22.6	20.68	0.954
No. 7.—Central Drift	1929	11	22.7	22.0	25.0	21.4	26.0	21.2	26.0	26.8	23.89	0.711
	1930	8	20.9	20.8	26.3	21.6	27.7	21.0	26.2	26.9	23.92	0.868
	1931	7	10.6	12.9	13.8	12.5	13.3	12.6	14.1	13.1	12.86	1.071
No. 8.—Southern Drift	1929	13	14.8	15.7	17.1	14.1	19.0	15.7	17.0	18.4	16.48	0.627
	1930	20	20.2	21.7	24.1	20.2	23.8	20.8	23.5	24.8	22.39	0.773
	1931	10	8.1	8.9	10.2	7.7	9.6	8.5	10.1	10.2	9.16	1.602
No. 9.*—South Western Area	1929	22	19.6	19.5	22.6	19.7	23.5	18.8	22.9	22.8	21.18	0.506
	1930	26	16.7	17.0	19.9	16.8	20.8	17.1	19.2	20.2	18.46	0.400

*No comparable records in Districts 3 and 9 in 1931 on account of drought.

TABLE 2.—RESULTS OF ANALYSIS OF VARIANCE OF YIELD

District	Year	Treatment mean squares							Error	
		Single elements			Interaction effects				Degrees of freedom	Mean square
		N.	P.	K.	NXP.	NXK.	PXK.	NXPXK.		
No. 1. Red River Valley	1929	62.84†	445.10†	0.21	3.57	0.01	0.09	0.45	63	5.15
	1930	130.39†	204.84†	0.00	13.78	1.06	0.74	8.21	70	6.20
	1931	52.00†	462.24†	0.86	3.32	1.33	6.67	0.02	63	4.69
No. 2. Assiniboine Delta	1929	116.03†	482.57†	2.00	16.24	33.89	0.98	12.34	56	9.14
	1930	281.89†	112.28†	2.58	7.52	2.25	11.84	1.76	70	9.21
	1931	0.02	32.35†	0.00	1.29	0.88	0.93	1.02	49	3.38
No. 3. Riding Mountain Wash	1929	6.10	255.45†	0.22	19.62*	0.01	1.26	2.88	14	4.29
	1930	53.10†	43.04†	0.43	0.08	0.84	2.38	0.04	14	3.01
No. 4. Dauphin Area	1929	35.28†	284.41†	0.00	10.81	0.00	3.12	0.20	21	2.73
	1930	51.54	216.18†	1.62	5.07	0.13	4.08	5.30	14	19.57
	1931	38.44†	11.56*	16.00*	0.20	0.20	4.20	2.90	7	1.63
No. 5. Swan River Valley	1929	43.47*	145.54†	0.01	17.57	6.64	2.97	1.55	28	5 97
	1930	135.47	53.10	79.21	1.24	0.84	16.93	25.30	14	30.61
	1931	8.82	406.12†	17.40	0.03	3.25	3.25	1.63	21	21.84
No. 6.—Northern Drift	1929	42.13*	847.48†	11.72	24.57	14.49	2.67	7.44	98	8.80
	1930	88.48†	345.84†	2.22	0.01	2.12	0.81	9.73	105	6.94
	1931	7.93	612.89†	0.76	11.96	11.70	11.59	9.03	91	12.73
No. 7.—Central Drift	1929	1.05	371.46†	0.13	8.91	0.21	20.62	0.76	70	5.58
	1930	1.91	521.15†	0.00	7.68	1.64	3.59	0.03	49	6.02
	1931	0.64	28.29	2.74	13.80	7.14	1.86	2.84	42	8.03
No. 8.—Southern Drift	1929	54.96†	203.84†	3.62	0.65	0.06	0.02	2.39	84	5.11
	1930	24.81	36.23	0.57	2.29	1.10	4.34	15.60	133	11.95
	1931	1.77	60.03	0.04	4.66	0.50	1.95	0.67	63	25.65
No. 9. South Western Area	1929	0.02	562.70†	2.53	10.55	8.86	0.01	0.08	148	5.66
	1930	21.08*	511.48†	4.82	5.61	0.01	6.74	0.00	175	4.16

*Indicates treatment mean square significantly greater than error; value of z between 5% and 1% point.
†Indicates treatment mean square significantly greater than error; value of z beyond 1% point.

TABLE 3.—EFFECT OF SINGLE ELEMENTS ON YIELD IN BUSHELS PER ACRE

District	Year	With N.	Without N.	Difference	With P.	Without P.	Difference	With K.	Without K.	Difference	Standard error of difference
No. 1.—Red River Valley	1929	26.8	25.1	1.7	28.3	23.6	4.7	25.9	26.0	−0.1	0.359
	1930	24.7	22.2	2.5	25.0	21.9	3.1	23.4	23.4	0.0	0.375
	1931	22.7	21.0	1.7	24.2	19.4	4.8	21.8	22.0	−0.2	0.343
No. 2.—Assiniboine Delta	1929	26.9	24.3	2.6	28.2	23.0	5.2	25.4	25.8	−0.4	0.500
	1930	25.9	22.3	3.6	25.2	23.0	2.2	24.3	23.9	0.4	0.456
	1931	13.8	13.8	0.0	14.5	13.1	1.4	13.8	13.8	0.0	0.325
No. 3.—Riding Mountain Wash	1929	23.3	22.3	1.0	26.0	19.5	6.5	22.9	22.7	0.2	0.598
	1930	25.2	22.2	3.0	25.0	22.4	2.6	23.6	23.8	−0.2	0.501
No. 4 Dauphin Area	1929	19.1	17.0	2.1	21.0	15.1	5.9	18.1	18.1	0.0	0.413
	1930	24.9	22.0	2.9	26.4	20.4	6.0	23.7	23.2	0.5	0.545
	1931	27.8	24.7	3.1	27.1	25.4	1.7	27.3	25.3	2.0	0.452
No. 5.—Swan River Valley	1929	30.0	28.0	2.0	30.9	27.1	3.8	29.0	29.0	0.0	0.546
	1930	20.1	15.3	4.8	19.2	16.2	3.0	19.5	15.9	3.6	0.600
	1931	31.4	30.3	1.1	34.4	27.3	7.1	31.6	30.1	1.5	1.170
No. 6.—Northern Drift	1929	27.0	25.9	1.1	29.1	23.8	5.3	26.8	26.1	0.7	0.367
	1930	24.0	22.4	1.6	24.9	21.6	3.3	23.3	23.1	0.2	0.329
	1931	20.4	20.9	−0.5	23.0	18.3	4.7	20.6	20.7	−0.1	0.477
No. 7. Central Drift	1929	24.0	23.8	0.2	25.9	21.8	4.1	23.9	23.9	0.0	0.355
	1930	24.1	23.8	0.3	26.8	21.1	5.7	23.9	23.9	0.0	0.434
	1931	13.0	12.8	0.2	13.6	12.2	1.4	13.1	12.7	0.4	0.535
No. 8.—Southern Drift.	1929	17.2	15.8	1.4	17.9	15.1	2.8	16.3	16.7	−0.4	0.313
	1930	22.8	22.0	0.8	24.1	20.8	3.3	22.4	22.5	−0.1	0.386
	1931	9.3	9.0	0.3	10.0	8.3	1.7	9.1	9.2	−0.1	0.801
No. 9.—Southwestern Area	1929	24.5	24.5	0.0	26.6	22.4	4.2	24.4	24.7	−0.3	0.253
	1930	18.8	18.1	0.7	20.0	16.9	3.1	18.3	18.6	−0.3	0.200
No. 1.—Average all plots	29–31	24.72	22.76	1.96	25.82	21.66	4.16	23.69	23.79	−0.10	0.208
No. 2.—Average all plots	29–31	22.74	20.52	2.22	23.11	20.15	2.96	21.64	21.62	0.02	0.260
No. 3.—Average all plots	29–30	24.23	22.25	1.99	25.54	20.94	4.60	23.22	23.26	−0.04	0.390
No. 4.—Average all plots	29–31	22.97	20.38	2.59	24.19	19.16	5.03	21.98	21.37	0.61	0.476
No. 5.—Average all plots	29–31	28.00	25.59	2.41	29.15	24.44	4.71	27.50	26.09	1.41	0.590
No. 6.—Average all plots	29–31	23.91	23.09	0.82	25.70	21.30	4.40	23.63	23.37	0.26	0.228
No. 7.—Average all plots	29–31	21.07	20.81	0.26	22.88	19.00	3.88	20.98	20.90	0.08	0.247
No. 8.—Average all plots	29–31	17.98	17.11	0.87	18.94	16.15	2.79	17.46	17.63	−0.17	0.274
No. 9.—Average all plots	29–30	19.88	19.54	0.34	21.38	18.04	3.34	19.57	19.85	−0.28	0.159

the other hand, when two or more elements gave increase when applied singly, their combination invariably resulted in a greater increase than that secured from both elements singly.

TABLE 4.—SUMMARY OF FERTILIZER TRIALS WITH WHEAT IN MANITOBA ARRANGED (A) FROM SOUTH TO NORTH AND (B) FROM EAST TO WEST (3 YEAR AVERAGE, 1929-30-31)

A. Average increase in per cent by districts from south to north						B. Average increase in per cent by districts from east to west					
District	Mean yield of checks per acre	Increase or decrease in per cent with: N	P_2O_5	K_2O	Standard error	District	Mean yield of checks per acre	Increase or decrease in per cent with: N	P_2O_5	K_2O	Standard error
	Bus.						Bus.				
1	20.9	8.51	19.49	−0.50	0.878	Average					
2	18.8	8.24	14.46	−0.08	1.206	of 1, 2					
3*	20.6	8.78	22.19	−0.20	1.685	and 3		8.51	18.71	−0.26	
4	18.8	12.75	24.38	3.41	1.231	6	20.8	3.04	20.80	0.87	1.014
						8	14.4	5.22	18.45	−1.16	3.038
5	21.8	13.23	19.38	8.85	3.326	7	18.1	1.40	19.04	1.00	1.594
						9*	18.1	1.58	18.39	−1.33	0.807

*2 yrs. 1929–1930 only.

SUPPLEMENTARY TRIALS

As a result of the earlier trials, the use of ammonium phosphate 10–48 was recommended in districts 1, 2, 3, 4 and 6, and the practice of applying this fertilizer was adopted on a large number of farms with the same beneficial results as were secured in the three-year trials here reported. However, in the most northerly district (5, Swan River Valley) a number of farmers reported that the ammonium phosphate alone did not give the marked increase expected. Greenhouse experiments indicated that this was due to the fact that the ammonium phosphate 10–48 did not contain sufficient nitrogen in combination with the phosphate for this area. Consequently acre field trials were conducted on a number of farms in the Swan River Valley during the season of 1932. The field yields obtained are shown in Table 5.

TABLE 5.—FERTILIZER TRIALS IN THE SWAN RIVER VALLEY, 1932

Farm	Check	Yields of wheat in bushels per acre treated with: Triple superphosphate	Ammonium phosphate	Ammonium phosphate and ammonium sulphate	Ammonium phosphate and potassium sulphate
1	35.0	49.9	54.6	60.1	55.4
2	31.1	32.4	36.2	44.7	45.7
3	28.7	37.7	33.1	39.1	40.3
Means	31.6	40.0	41.3	48.0	47.1
		Yields of oats in bushels per acre:			
4	62.8	95.5	106.6	103.0	102.2

The field and greenhouse trials supplementary to the three-year trials indicate therefore that mono-ammonium phosphate does not carry sufficient nitrogen along with the phosphate in this northern area, and that greater amounts of nitrogen should be applied with the phosphate similar to the quantities used in the three-year trials.

The conclusions from all the Swan River trials are that nitrogen is as important as phosphate in the northern belt, but that potash response is either seasonal or the result of local requirement only.

ZONATION AND FERTILIZER RECOMMENDATIONS

The field trials in the nine agricultural districts investigated and reported above, indicate three groups of districts according to fertilizer requirements when the drilling-in method is used (see Figure 4).

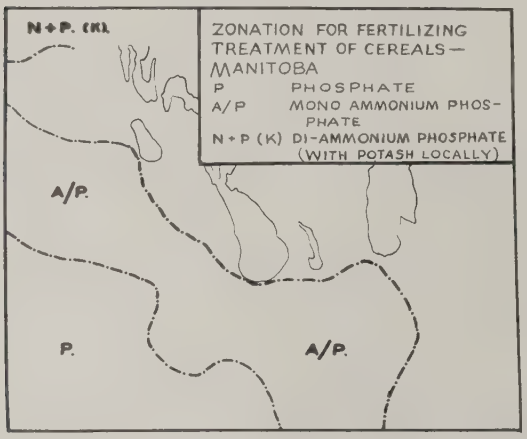

FIGURE 4. Zonation for fertilizer treatment of wheat indicated by the fertilizer trials.

(1) Significant response to phosphate only (districts 7, 8 and 9).

(2) Significant response to nitrogen and phosphate (districts 1, 2, 3, 4 and 6).

(3) Response to nitrogen and phosphate, with indications of local requirements of potash (district 5).

The geographical occurrence of these three groups of districts shows that their distribution is coincident with three major genetic soil belts, which occur as follows:—

A. Prairie soils.

Belt. 1. Normal chernozem, or southern belt.

Belt. 2. Northern chernozem, or intermediate belt.

B. Wooded area.

Belt. 3. Woodland invasion of northern chernozem and forest-soils, or northern belt.

1. ***Southern belt.*** The southern belt is located in the southwestern portion of the province and comprises agricultural districts 7, 8 and 9. The phytomorphic soils of this belt are typical chernozem or black-earth soil type; in the virgin condition they are prairie grass-land soils developed on drift or modified drift. Phosphate only gave significant response in the fertilizer experiments throughout this belt. Hence fertilizers of the triple superphosphate type should be recommended as the basic fertilizer for cereals in this zone.

2. ***Intermediate belt.*** Extending above the northern and eastern edge of the normal chernozem belt is a group of soil combinations which form a transitional belt between the normal black-earth soils and the wooded soils belt. In Manitoba, from east to west, these soil combinations include: (a) the black-earth and meadow-prairie soils on the deep lacustrine clays of Lake Agassiz; (b) The sandy chernozem-like soils of the Assiniboine Delta; (c) The northern chernozem (or northern black earth) soils on drift; and (d) Soils developed under woodland invasion on lacustrine sediments, modified drift and drift.

This intermediate belt includes agricultural districts 1, 2, 3, 4 and 6. Throughout this belt, which may be classed as the northern portion of the Manitoba prairies under aspen grove invasion as park land, phosphate gave the most significant increase in yield, but nitrogen in addition gave a smaller though significant response. Hence a fertilizer of the mono-ammonium phosphate type should be recommended as the basic fertilizer for the northern portion of the prairies.

Throughout the prairie region, namely in both the southern belt and the intermediate belt, there is no indication that potash for cereals is required generally.

3. ***The northern belt.*** Only one district of the grain growing area of the province (district 5) is included in this belt. The soils of this area were developed under forest or recent woodland invasion. The fertilizer trials to date in this area indicate: (a) that additional amounts of nitrogen are required with the phosphate than are required in the intermediate belt; (b) that a nitrogen and phosphate fertilizer of the di-ammonium phosphate type should be used as the basic combination throughout the district; and (c) that potash may be required in certain locations only.

NITRATE NITROGEN VS. AMMONIACAL NITROGEN

In the three-year fertilizer trials throughout the nine agricultural districts, two fertilizers were used as carriers of nitrogen where nitrogen was used alone, namely, ammonium sulphate and sodium nitrate. A comparison of the yields for these two fertilizer treatments for each of the nine districts in each of the three years shows an average increase of 1.31 bushels more when treated with ammonium sulphate than when treated with the sodium nitrate. This difference though small is highly significant. By grouping the average yield-increase of the nine districts into the three belts, the increases are shown to be progressive from south to north. In the southern belt (districts 7, 8, and 9) the increase from the ammonium sulphate treatment over the sodium nitrate treatments was .50 bushels. In the intermediate belt (districts 1, 2, 6, 3 and 4) the increase was 1.40 bushels. In the northern belt (district 5) the increase was 3.03 bushels. In general the sodium nitrate gave little or no response over the check, and in the dry seasons the nitrate tended to retard early growth and to depress slightly the yields in the southern belt.

WEATHER

The general weather conditions which prevailed during the three years the experiment was conducted are shown in Table 6. The average figures given are compiled from reports from the 25 meteorological stations located in the area investigated. The precipitation and temperature

figures for each of the three crop seasons of 1929, 1930 and 1931 were averaged for the stations in each district, and include the mean figures for the autumn months prior to the crop season (August to October) and for the growing months (April to July) only. The figures for the months in which the mean temperature was below freezing, namely, November to March, were not included, as the weather conditions of this period have little effect on the crop. The respective normal precipitation and temperature figures are presented in the same table for comparison. As a single expression value of precipitation and temperature a climatic factor was calculated similar to that used by McKibbin (*4*). The climatic factor here used is the total precipitation in inches for the seven months (fall and growing season) (P) divided by the respective difference between the mean monthly temperature and 32° F. (T) for the corresponding period. The higher values obtained by this method indicate relatively moist conditions, and inversely the lower values indicate drier conditions.

The figures in Table 6 indicate that the season of 1929, and to a greater extent the season 1931 were drier than the normal, while the season of 1930 approached the normal in precipitation, with higher than normal temperature. However, owing to the fact that the data for a number of the stations were incomplete, the mean figures can be used only to give a general idea of the conditions over the area as a whole. The stations are not sufficiently well distributed within each agricultural district, to justify the working out of correlations either with the district crop yields or the fertilizer increases by districts. The "climatic-factor" figures indicate however that during the three years of the experiment, the weather conditions were not the most favorable for crop production.

TABLE 6.—MEAN RAINFALL, TEMPERATURE, AND CALCULATED CLIMATIC FACTOR,* FOR THE PREVIOUS FALL MONTHS (AUGUST TO OCTOBER) AND THE GROWING SEASON (APRIL TO JULY) BY DISTRICTS, 1929, 1930 AND 1931

District	Precipitation P				Temperature T				Climatic factor P/T—32° F.			
	Normal	1929	1930	1931	Normal	1929	1930	1931	Normal	1929	1930	1931
		Inches				Degrees Fahrenheit						
1	14.89	8.43	13.73	9.50	53.3	53.0	55.6	55.4	.70	.40	.58	.41
2	14.15	7.08	14.68	9.27	53.6	53.0	55.4	55.2	.65	.34	.63	.40
3	—	—	—	—	—	—	—	—	—	—	—	—
4	13.33	—	8.77	7.31	51.4	53.0	55.8	55.3	.69	—	.37	.31
5	—	—	—	—	—	—	—	—	—	—	—	—
6	13.33	8.16	13.38	8.09	51.6	49.4	52.2	52.4	.68	.47	.66	.40
7	13.15	9.55	18.18	6.99	52.1	50.9	53.9	54.7	.65	.50	.83	.31
8	13.49	7.59	14.55	—	52.9	52.1	54.8	—	.64	.38	.64	—
9	12.43	8.62	10.97	7.05	52.7	52.1	55.1	55.4	.60	.43	.47	.30

*"Climatic-factor" here used $\frac{\text{precipitation}}{\text{mean monthly temperature minus 32° F.}}$

POTENTIAL FERTILITY OF MANITOBA SOILS

A fundamental difference exists between the use of fertilizer to supply a deficiency to total nutrients in "deficient" soils, and in its use in the northern prairies to provide supplementary nutrients for crop stimulation during the critical early growth period. However, for purposes of com-

parison with other regions the potential fertility of the soils in the area covered is presented in summary form. The summary of the soil analyses here reported was compiled from a number of analyses of soils collected by Clevenger (*1*) from the areas subsequently covered by the fertilizer trials. The total nitrogen was determined by the Kjeldahl method and the phosphorus was determined by the fusion with magnesium nitrate method. All soil samples were taken to a depth of six and two-thirds inches. The 192 nitrogen determinations were made on cultivated soils. The 208 phosphorus determinations were made chiefly on cultivated soil, but include also 16 virgin samples, the phosphorus content of which was of similar values to those found in cultivated soils. These analyses were grouped by combining and averaging the percentage figures for the heavy to medium textured soils, and for the light textured soils in each of the three belts. The summaries are presented in Table 7.

The mean figures given in Table 7 lead to the conclusion that the soils of the area in which the fertilizer trials were conducted are of high average potential fertility, and that they are not commonly deficient in these two elements, with the possible exception of the lower values for phosphorus in the light textured soils of the southern belt. The figures compare very favorably with average regional figures from other areas. Hence the general response secured from the drilling-in of small quantities of phosphate in prairie soils, and of phosphate with the addition of nitrogen in the more northern portion of the prairies, is not due to the low values for total nutrients, but the increases appear to be related to climatic conditions, availability, and rate of intake. This phase of the problem requires treatment as a separate study.

TABLE 7.—TOTAL NITROGEN AND TOTAL PHOSPHORUS IN MANITOBA SOILS

Agricultural District	Soil belt	Heavy to medium textured soils			Light textured soils		
		No. of soil samples	Percentage of total nitrogen	Pounds per acre, 6⅔ inches	No. of soil samples	Percentage of total nitrogen	Pounds per acre, 6⅔ inches
		Percentage total nitrogen and pounds per acre 6⅔ inches					
5	(3) Northern	20	.494	9880	4	.277	5540
1, 2, 3, 4, 6	(2) Intermediate	87	.405	8100	29	.302	6040
7, 8, 9	(1) Southern	34	.360	7200	18	.269	5380
Total		141			51		
		Percentage total phosphorus and pounds per acre 6⅔ inches					
5	(3) Northern	21	.085	1700	4	.089	1780
1, 2, 3, 4, 6	(2) Intermediate	102	.082	1640	28	.070	1400
7, 8, 9	(1) Southern	35	.076	1520	18	.061	1220
Total		158			50		

SUMMARY

1. Complete fertilizer trials with wheat, in which small quantities of eight different fertilizers were applied below the seed, were conducted throughout the grain growing area of Manitoba during 1929, 1930 and 1931. The area of the trials covered nine agricultural districts. The

records of the individual trials were compiled and the mean yields of the various treatments for each district obtained.

2. Three types of response were noted:

I. Significant and marked response to phosphate.

II. Significant and marked response to phosphate; and significant though smaller increase with nitrogen.

III. Significant response to both nitrogen and phosphate, with a local tendency for potash to give increased yields.

3. The response to nitrogen decreased from north to south, whereas phosphate gave response throughout. Potash gave no significant response in any of the prairie soils. Where increases were secured from nitrogen alone, ammonium sulphate proved superior to sodium nitrate.

4. The three types of response obtained coincide with three major soil belts, and hence the zonation for the fertilizer requirement of wheat in the northern prairie region is indicated, namely: (a) phosphate in the southern belt; (b) phosphate with small amounts of nitrogen in the northern portion of the northern prairies; and (c) nitrogen and phosphate in the wooded belt, with the addition of potash where required on local soils only.

5. The weather conditions which prevailed during the three seasons were shown to be less favorable than normal for crop production in two out of the three years.

6. The average total nitrogen and phosphate content of the soils of the area covered by the fertilizer trials is shown to be relatively high. Hence the trials were conducted on "potentially fertile" and not on "deficient" soils.

7. The introduction of the practice of drilling-in small quantities of fertilizer with the seed may be classed as one of the most important contributions to cereal production in Western Canada. In the majority of cases where the practice has been followed, marked increases in yield with other advantages have been obtained, even on soils famed for their high fertility. The reason for the general response of cereals to this method of fertilization under these conditions appears to be related to climatic conditions, availability of nutrients, and rate of intake, but the fundamental causes require investigation.

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Résumé

Division en zones des prairies du nord au point de vue des engrais chimiques. J. H. Ellis, Service des sols, Département de l'Agronomie, Université du Manitoba.

Des essais d'engrais complets sur le blé, dans lesquels de petites quantités de huit espèces différentes d'engrais ont été appliquées par-dessous la semence, ont été conduits dans la région à grain du Manitoba en 1929, 1930 et 1931; ils couvraient au total neuf districts agricoles. Les notes prises sur les essais séparés ont été compilées et on a relevé les rendements moyens des différents traitements pour chaque district.

Trois genres d'action ont été notés: I. Action significative et marquée du phosphâte; II. action significative et marquée du phosphate et significative, quoique plus faible, avec l'azote; III. action significative de l'azote et du phosphate, avec tendance locale pour la potasse à provoquer une augmentation de rendement.

L'action de l'azote diminuait en allant du nord au sud tandis que l'action du phosphate était prononcée partout. La potasse n'a exercé aucune action significative sur les sols des Prairies, quels qu'ils soient. Là où l'azote était seul employé, le sulfate d'ammonium s'est montré supérieur au nitrate de soude. Les trois types d'action coïncident avec les trois bandes principales de sol et c'est pourquoi la division en zones de la région du nord des prairies au point de vue des engrais nécessaires pour le blé est nettement indiquée, savoir: (a) phosphate dans la zone du sud; (b) phosphate avec de petites quantités d'azote dans la partie la plus au nord; et (c) azote et phosphate dans la zone boisée, avec l'addition de potasselorsque cela est nécessaire sur les sols locaux seulement. Les conditions de température qui ont régné pendant les trois saisons ont été moins favorables que la normale pour la production des récoltes dans deux années sur trois. On voit que la moyenne totale de la proportion d'azote et de phosphate dans les sols de la région couverte par les essais d'engrais chimiques est relativement élevée et que les essais ont été conduits sur les sols "potentiellement fertiles" et non pas sur des sols "dépourvus de fertilité". L'introduction de la pratique qui consiste à semer de petites quantités d'engrais avec la semence peut être classée comme l'une des contributions les plus importantes dans la production des céréales dans l'Ouest du Canada. Dans la majorité des cas où la pratique a été suivie, on a obtenu des augmentations sensibles de rendement ainsi que d'autres avantages, même sur des sols renommés pour leur haute fertilité. La raison de l'action exercée sur les céréales par ce mode de fertilisation dans ces conditions paraît être reliée aux conditions climatériques, à l'assimilabilité des principes fertilisants et au taux d'absorption, mais les causes fondamentales restent encore inconnues.

NUTRITIONAL STUDIES WITH CHRYSANTHEMUMS[1]

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MATERIALS AND METHODS

For several years chrysanthemums have been grown extensively in pots in the greenhouse at the Central Experimental Farm. From time to time many of the plants have been disfigured by foliage troubles, consisting of yellow streaking or mottling of the leaves, brown or reddish spotting and general lack of vigour. Experience derived from nutritional studies with other plants indicated that these troubles might be due to nutritional deficiences or lack of balance between nitrogen and the mineral elements. Plants were, therefore, grown in ground sand-stone in pots in the greenhouse and subjected to the following nutrient solutions. Each series consisted of five plants. The variety Sir William Clark was used.

1. Normal solution
2. Normal solution + nitrogen
3. Normal solution + (nitrogen × 2)
4. Normal solution + (nitrogen × 3)
5. Normal solution − $\frac{1}{2}$ nitrogen
6. Normal solution − $\frac{1}{4}$ nitrogen
7. Normal solution + (nitrogen + potassium)
8. Normal solution + (nitrogen + potassium) × 2
9. Normal solution + (nitrogen + potassium) × 3
10. $\frac{1}{2}$ Normal solution
11. Normal solution + phosphorus
12. Normal solution + phosphorus + potassium
13. Normal solution + nitrogen + phosphorus
14. Normal solution + (nitrogen + phosphorus) × 2
15. Normal solution + (nitrogen + phosphorus) × 4
16. Normal solution lacking potassium
17. Normal solution lacking (phosphorus + $\frac{2}{3}$ potassium)
18. Normal solution + potassium
19. Normal solution + (potassium × 2)
20. Normal solution + (potassium × 3).

Stock nutrient solutions

$MgSO_4.7H_2O$	140 gms. in 2000 cc. water
KH_2PO_4	70 gms. in 2000 cc. water
$CaCl_2$	150 gms. in 2000 cc. water
NH_4NO_3	360 gms. in 4000 cc. water
$MnSO_4$	1 gm. in 2000 cc. water
H_3BO_3	1 gm. in 1000 cc. water
KNO_3	50 gms. in 1000 cc. water
$NH_4H_2PO_4$	70 gms. in 2000 cc. water

[1] Contribution from the Laboratory of Plant Physiology, Horticultural Division.

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From these stock solutions the different solutions were made up as required. Below is given the amount of stock solutions made up to 5000 cc. to make a normal solution.

$MgSO_4.7H_2O$	70 cc.
KH_2PO_4	77 cc.
$CaCl_2$	74 cc.
NH_4NO_3	44.5 cc.
$MnSO_4$	5.3 cc.
H_3BO_3	28 cc.
Ferric chloride	10 cc. of 0.5% solution.

In solutions requiring excess of certain elements, additional potassium was added in the form of potassium nitrate, the nitrogen content being adjusted to agree with the normal. Additional phorphorus was added in the form of monoammonium phosphate, the nitrogen content being adjusted. In solutions lacking potassium, phosphorus was supplied in the form of monoammonium phosphate. In solutions lacking phosphorus, potassium was supplied in the form of potassium nitrate, the nitrogen content of the solution being adjusted. Solutions were fed twice a week at the rate of 200 cc. per pot.

In Table 1 are given the parts per million of the elements of the solutions fed.

TABLE I.—PARTS PER MILLION OF ELEMENTS IN THE SOLUTIONS FED

Series	N	P	K	Mg.	Ca.	S	Mn.	B	Fe	Total
1	278	122.8	154.8	96.4	400	127	0.19	1.0	3.44	1185.24
2	556	122.8	154.8	96.4	400	127	.19	1.0	3.44	1463.24
3	834	122.8	154.8	96.4	400	127	.19	1.0	3.44	1741.24
4	1112	122.8	154.8	96.4	400	127	.19	1.0	3.44	2019.24
5	139	122.8	154.8	96.4	400	127	.19	1.0	3.44	1046.24
6	208	122.8	154.8	96.4	400	127	.19	1.0	3.44	1115.24
7	556	122.8	309.6	96.4	400	127	.19	1.0	3.44	1804.00
8	834	122.8	464.4	96.4	400	127	.19	1.0	3.44	2050.84
9	1112	122.8	619.2	96.4	400	127	.19	1.0	3.44	2483.64
10	139	61.4	77.4	48.2	200	63.5	.19	1.0	3.44	5957.40
11	278	245.6	154.8	96.4	400	127	.19	1.0	3.44	1308.04
12	278	245.6	309.6	96.4	400	127	.19	1.0	3.44	1462.84
13	556	245.6	154.8	96.4	400	127	.19	1.0	3.44	1586.04
14	834	368.4	154.8	96.4	400	127	.19	1.0	3.44	1986.84
15	1390	614.0	154.8	96.4	400	127	.19	1.0	3.44	2788.44
16	333.4	122.8	—	96.4	400	127	.19	1.0	3.44	1085.84
17	297.4	—	51.8	96.4	400	127	.19	1.0	3.44	978.84
18	278	122.8	309.6	96.4	400	127	.19	1.0	3.44	1340.04
19	278	122.8	464.4	96.4	400	127	.19	1.0	3.44	1494.84
20	278	122.8	619.2	96.4	400	127	.19	1.0	3.44	1649.64

EXPERIMENTS WITH VARIETY SIR WILLIAM CLARK

Foliage and Growth Characteristics

Plants receiving the normal solution were fairly vigorous, with the foliage tending to be somewhat light green in colour and a few of the extreme bottom leaves drying and dying, this injury commencing as a marginal chlorosis, later involving large areas between the veins and eventually

FIGURE 1. Marginal chlorosis due to excess feeding of nitrogen.

FIGURE 2. More advanced stage of chlorosis due to excess feeding of nitrogen or a high nitrogen-potassium ratio.

causing burning and dying of the affected leaves (see Figures 1 and 2). As the nitrogen application was increased in Series 2, 3 and 4 the plants increased in vigour, the foliage became darker green in colour and the leaves larger in size. However, with the increase of nitrogen there was a corresponding increase of burning and dying of the leaves from the base of the plant up, until in Series 3 and 4 the foliage was burnt and dying for a foot to half way up the plant. The upper half of the plant was characterized by marked chlorosis gradually decreasing in severity so that the leaves at the top of the plant showed but slight marginal chlorosis. Series 5, receiving but half the normal amount of nitrogen, was lacking in vigour, with small leaves; the foliage was light green in colour, with the lower leaves yellowish with reddened veins. Series 6 was slightly more vigorous than Series 5, with slightly better coloured foliage. Where nitrogen and potassium were increased together, vigorous strong plants were obtained, with foliage of good dark green colour, burning of the foliage being restricted to a very few leaves at the base of the plant. All the plants in this group were better than those in the normal series, increasing in vigour and growth up to Series 9, which had the most vigorous growth and best coloured foliage of the experiment. Potassium had a marked effect in overcoming the burning and dying of the leaves on the lower part of the plant caused when nitrogen alone was increased, as in Series 3 and 4 (See Figures 3 and 4). The series receiving but half the normal solution was decidedly reduced in vigour; the foliage was light green with the lower

FIGURE 3. Browning and dying of the foliage from the base of the plant upwards, due to heavy feeding of nitrogen or nitrogen and phosphorus.

leaves pinkish red and spotted with red blotches. Adding an additional supply of phosphorus to the normal solution produced plants lacking in vigour, with burning and dying of the lower leaves and yellowish to reddish discolouration of the foliage (See Figure 3). Where phosphorus and potassium were increased together the growth tended to be spindly, foliage light green in colour, not equalling the normal solution. Increasing both the nitrogen and phosphorus together produced plants with similar injury to Series 3 and 4; where nitrogen alone was increased, the extent of the injury was somewhat more severe. The addition of phosphorus was not able to nullify the effect of excessive nitrogen but rather increased it. Lack of potassium was characterized by poor vigour, fading and yellow browning of the foliage, together with burning and dying of the foliage to within a short distance of the growing tips (See Figure 5). The burning and dying of the foliage from the base up was similar to that brought about by high nitrogen applications when potassium was not increased at

FIGURE 4. Foliage healthy to the base of the plant. Solution 3N+3K.

the same time. The upper foliage was characterized by chlorotic areas similar to that caused by excess nitrogen feeding.

Lack of phosphorus was characterized by a great reduction in vigour, stunting and reddish-purpling of the leaves. The lower leaves that had died were reddish-purple in colour. The mottling was not a distinct chlorosis as in the case of excess nitrogen but rather a difference in the intensity of the basic green colour of the leaf. It did not commence at the margin as in the case of excess nitrogen feeding but occurred in irregular patches anywhere in the leaf.

Plants receiving additional potassium had somewhat light green foliage but good vigour, much better than the normal series. The lower leaves were faded to a yellow brown with slight yellow mottling.

A check series growing in soil had very good growth, but considerable burning and dying of the lower leaves, with yellow mottling higher up the plant.

In Table 2 are tabulated data regarding growth and bloom. Increased applications of nitrogen in Series 2, 3 and 4 caused a marked increase in the number of blossom buds, despite the burning and dying of the lower foliage, and had a tendency to delay the time of blooming. Reduction of nitrogen in the solution did not cause any reduction in the number of blossom buds, as compared with the normal, but retarded growth, as evidenced by a decrease in the height of the plants. Increasing nitrogen and potassium together in Series 7, 8 and 9 caused a much greater increase of blossom buds than when nitrogen alone was increased, Series 9 having

the greatest average number of blossom buds in the experiment. Vigour, as represented by height of plant, was also increased, along with the size of bloom. Increasing the phosphorus in the normal solution did not increase the number of blossom buds and had a retarding effect on the date of blooming. Increasing nitrogen and phosphorus together in Series 13, 14 and 15 caused a decrease of blossom buds as compared with increasing

FIGURE 5. Plant on left lacking potassium. Plant on right lacking phosphorus.

nitrogen alone. It also caused a decrease in vigour, a marked reduction in the size of bloom and a retarding effect on the date of blooming. Increased concentrations of potassium caused a decided increase in blossom bud production, good vigour and good size of bloom but not as great an increase as when nitrogen and potassium were increased together.

TABLE 2.—GROWTH AND BLOOM DATA

Series	Average height in inches	Average number of blossom buds per plant	Date of blooming	Average size of bloom, in.	Colour
1	54	62	Oct. 24	3.00	Orange to ochraceous orange.
2	54	82	Oct. 25	2.75	Orange to ochraceous orange.
3	51	109	Oct. 27	3.00	Empire yellow tinged with orange.
4	48	109	Oct. 27	2.50	Empire yellow tinged with orange.
5	46	65	Oct. 25	2.75	Orange to ochraceous orange.
6	48	68	Oct. 25	2.75	Orange to ochraceous orange.
7	54	116	Oct. 25	3.00	Orange to ochraceous orange.
8	57	128	Oct. 22	3.25	Orange to ochraceous orange.
9	65	170	Oct. 23	3.25	Orange to ochraceous orange.
10	52	57	Oct. 28	2.50	Orange to ochraceous orange.
11	47	61	Oct. 27	2.75	Empire yellow tinged with orange.
12	48	83	Oct. 26	2.75	Orange to ochraceous orange.
13	45	78	Oct. 25	2.50	Empire yellow tinged with orange.
14	46	86	Oct. 28	2.25	Empire yellow tinged with orange.
15	43	94	Oct. 28	2.00	Lemon chrome.
16	41	56	Oct. 29	2.00	Lemon chrome.
17	42	48	Oct. 28	2.25	Ochraceous orange.
18	52	97	Oct. 25	2.75	Orange to ochraceous orange.
19	56	97	Oct. 25	3.00	Ochraceous orange.
20	57	129	Oct. 27	3.00	Ochraceous orange.
Soil	60	112	Oct. 28	3.00	Ochraceous orange.

Colour of Bloom

One of the most outstanding features of the experiment was the effect of the different nutrient solutions on the colour of the bloom, ranging from ochraceous orange to a lemon chrome (See Plate I).

Increasing the nitrogen from the normal solution brought about a gradual change from ochraceous orange to Empire yellow as the nitrogen concentrations increased. Decreasing the nitrogen from the normal caused a deepening of the orange colour as compared with the normal. Increasing the potassium with the nitrogen nullified the effect of high nitrogen concentration in producing yellow bloom. Increased phosphorus produced bloom ranging from Empire yellow to lemon chrome as the concentrations increased. Lack of potassium produced lemon chrome coloured bloom. Increased potassium over the normal produced the most highly coloured flowers, showing a gradual deepening of the orange colour as the potassium concentration increased (Plate I).

Chemical Ash Analysis

In analyzing the ash of plant material in this project, generally recognized methods from various sources were combined to give what seemed to be a satisfactory procedure. Table 3 gives the results from the analysis of the top ten inches of the plant in terms of ash constituents as percentage of ash.

The addition of nitrogen to the normal solution has resulted in a progressive decrease in K_2O accumulation in both ash and dry matter. There has been an almost corresponding increase in CaO in both ash and

PLATE I

Bloom colour of Sir William Clark

dry matter with no definite trend in either MgO or P_2O_5 in ash but a slight increase in dry matter. Conversely the reduction of nitrogen in the normal solution has resulted in an increase in K_2O accumulation in both ash and dry matter, a slight decrease in CaO, and a very marked decrease in MgO, in both ash and dry matter with no definite trend in P_2O_5.

TABLE 3.—ASH CONSTITUENTS AS PERCENTAGE OF ASH FROM TOP TEN INCHES OF [illegible]E PLANT

Series	Treatment	Dry matter in fresh weight	Percent ash in dry matter	CaO	Ash co[illegible] as [illegible]h		
					MgO	[illegible]	P_2O_5
1	Normal	19.5	5.93	23.74	13.26	36	16.97
2	+N	22.6	7.69	26.86	11.89	.25	16.86
4	+ N × 3	23.4	6.65	29.46	13.39	3.11	18.15
5	− ½ N	13.0	7.08	21.67	8.94	29.69	14.89
6	− ¼ N	19.2	6.77	22.24	9.58	25.89	17.21
7	+(N + K)	15.8	9.17	21.78	9.66	25.13	13.51
8	+(N + K) × 2	18.1	7.94	22.18	8.35	27.97	12.45
9	+(N + K) × 3	21.7	6.90	21.37	7.85	30.76	9.46
10	½ Normal	13.6	6.90	26.50	11.26	19.22	15.01
11	+ P	21.5	10.30	24.65	10.28	20.50	25.59
12	+(P + K)	15.8	10.06	19.32	7.87	30.51	19.79
13	+(N + P)	19.1	8.08	24.01	11.12	18.88	27.80
14	+(N + P) × 2	22.1	8.38	25.73	11.01	13.70	35.49
15	+(N + P) × 4	23.6	7.54	26.10	9.71	14.86	44.11
16	− K	15.5	6.57	31.08	15.02	4.17	28.47
18	+ K	17.7	6.73	19.78	7.47	33.27	13.30
19	+ K × 2	22.0	6.87	17.01	5.07	40.69	11.53
20	+ K × 3	13.2	8.01	16.87	3.57	41.29	9.73

The addition of both nitrogen and potassium to the normal solution has brought about a progressive increase in K_2O in ash and dry matter; a slight reduction in CaO accumulation in ash; a very marked reduction of MgO in ash and dry matter and a marked reduction in P_2O_5 in both ash and dry matter. There is also a considerable increase of total ash in dry matter. Increased feeding of phosphorus has resulted in a marked increase of that element in both ash and dry matter; a decrease in the amount of K_2O in ash but not in dry matter; a decrease in the amount of MgO in ash but not in dry matter; a slight increase in CaO in ash but a large increase in dry matter. The large percentage of total ash in dry matter in this series probably accounts for the differences when worked on a dry weight basis as compared with the results when worked on a percentage of ash basis. It will be noted that when phosphorus is increased in the solution either alone or with nitrogen there is a marked increase of total ash in dry matter. Additional increments of potassium have also had this effect to a less degree. Increased feeding of phosphorus and nitrogen has resulted in a marked decrease of K_2O in ash; a considerable increase in CaO in ash and dry matter; a decrease of MgO in ash but an increase in dry matter and a very marked increase in P_2O_5 in both ash and dry matter.

The withdrawal of potassium from the normal solution has resulted in a very marked decrease in K_2O in both ash and dry matter; a marked increase in CaO in both ash and dry matter; a slight increase in MgO in

ash and dry matter and a very marked accumulation of P_2O_5 in ash and dry matter. Increased feeding of potassium has resulted in a marked increase of that element in ash and in dry matter; a considerable decrease in CaO accumulation in ash and in dry matter and a very marked decrease of MgO and P_2O_5 in ash and in dry matter.

Discussion

A consideration of the foregoing results brings out the following features.

TABLE 4.—ASH CONSTITUENTS AS PERCENTAGE OF DRY WEIGHT

Series	Dry weight	Per cent K_2O	Per cent CaO	Per cent MgO	Per cent P_2O_5
Normal	9.5	1.24	1.31	0.73	0.94
+ N	22.6	1.19	1.95	.87	1.23
+ 3N	23.4	0.812	1.82	.83	1.12
− ½ N	13.0	1.99	1.45	.60	1.00
− ¼ N	19.2	1.66	1.43	.61	1.10
+ (N + K)	15.8	2.12	1.90	.84	1.18
+ (N + K) × 2	18.1	2.11	1.67	.63	.94
+ (N + K) × 3	21.7	2.02	1.40	.51	.62
½ Normal	13.6	1.24	1.71	.73	.97
+ P	21.5	1.95	2.41	1.00	2.50
+(P + K)	15.8	2.91	1.84	.75	1.89
+(N + P)	19.1	1.61	2.06	.95	2.38
+(N + P) × 2	22.1	1.09	2.04	.87	2.81
+(N + P) × 4	23.6	1.06	1.87	.69	3.15
− K	15.5	.258	1.92	.93	1.76
−(P + 2/3K)	17.9	.827	2.04	.94	1.19
+ K	17.7	2.06	1.22	.47	.82
+ K × 2	22.0	2.66	1.11	.33	.75
Top + K × 3	13.2	3.15	1.28	.27	.74
Middle	22.4	2.78	.95	.26	.61
Bottom	28.6	2.33	.95	.22	.34

There is a marked negative correlation of the nitrogen-potassium ratio in the nutrient solution on the accumulation of certain elements in the plant. When the ratio of nitrogen to potassium is high, potassium accumulation is decreased and calcium accumulation is increased with slight increases in MgO and P_2O_5 in dry matter. When this ratio is low the potassium accumulation is increased and calcium and magnesium accumulation markedly decreased. A low nitrogen-potassium ratio has a very marked effect on limiting the MgO accumulation. The above conditions hold true whether the change in nitrogen potassium ratio is brought about by varying either the nitrogen or potassium in the nutrient solution. Varying the potassium concentration in the nutrient solution appears to have an influence also independent of the nitrogen potassium ratio. The addition of potassium causes a marked decrease in the accumulation of P_2O_5 in the plant and the withdrawal of potassium causes a marked increase in P_2O_5 accumulation in the plant. There appears to be a marked negative correlation between these two elements similar to that reported in (*1*). The addition of phosphorus to the normal solution causes a decreased accumulation of potassium and an increased accumulation of CaO in ash.

There are certain outstanding points from the ash analysis which correlate to a degree with the foliage conditions and appearance of the plants. Burning of the lower foliage, chlorotic streaking of the younger growth and lack of colour development in the bloom were found in series receiving additional increments of nitrogen, series in which the potassium was withdrawn and series receiving additional increments of phosphorus. An examination of the ash analyses data from these treatments reveal certain things in common. Thus, they are all lower in potassium and all higher in calcium than the normal. In addition the plus phosphorus and minus potassium series were much higher in P_2O_5. In these latter series the injury to the plants was more severe.

Plants devoid of these injurious symptoms were found in the minus nitrogen series, the plus potassium series and series in which both nitrogen and the potassium were increased in proportion. The ash analysis revealed these plants to be all higher in potassium all lower in calcium and all much lower in magnesium than the normal. The plants receiving additional increments of potassium were also much lower in phosphorus and it was in these series that the best plants were produced with the best coloured bloom.

These foliage troubles and lack of development of bloom colour may therefore be associated with low potassium in plant ash, high calcium magnesium or phosphorus, brought about by widening the nitrogen-potassium ratio in the nutrient solution and by increasing the concentration of phosphorus. The plants in the normal solution showed some signs of foliage injury and lack of bloom colour. This was corrected by narrowing down the nitrogen-potassium ratio as in series 18 and 19. In light of the ash analysis it would be interesting to see if a similar result might be secured by cutting down the calcium, magnesium or phosphorus concentration in the arbitrary normal solution.

REPETITION ON VARIETIES MARIE ADELAIDE AND MRS. F. C. ELFORD

Subsequently, it was considered advisable to determine whether other varieties would respond to similar treatments in a like manner. The varieties Marie Adelaide and Mrs. F. C. Elford were employed, repeating the following treatments:—

1. Normal solution + (nitrogen × 3)
2. Normal solution − ½ nitrogen
3. Normal solution + (N + K) × 3
4. Normal solution + phosphorus
5. Normal solution + (N + P) × 4
6. Normal solution lacking potassium
7. Normal solution lacking phosphorus
8. Normal solution + (potassium × 3).

Foliage and Growth Characteristics

In general, the behaviour of both these varieties was similar, so that the following remarks are to be construed as pertaining to the two varieties unless otherwise noted.

Plants receiving additional increments of nitrogen showed very good vigour with the foliage dark green and the leaves large in size. However,

after exposure to the treatment for some time, burning and drying of the lower leaves occurred with mottling and chlorosis of the upper foliage, the injury commencing at the base of the plant and progressing upward. The behaviour of these two varieties was identical with that of Sir William Clark in the former experiment. Series 2, receiving but half the normal amount of nitrogen was lacking in vigour, the foliage being light green in colour. However, there was no burning, mottling or chlorosis of the foliage as in the previous series.

Where nitrogen and potassium were increased together, vigorous plants, with healthy green foliage were produced. There was no burning or chlorosis of the foliage. The addition of potassium almost completely eliminated the foliage injury caused when nitrogen alone was increased. An additional increment of phosphorus to the normal solution produced plants reduced in vigour, with foliage light green in colour. There was considerable burning of the lower leaves commencing as a marginal scorch, reddish in colour.

Increasing the nitrogen and phosphorus together produced excessive burning of the leaves extending from the base half-way up the plant. The upper foliage of the plants was a dull dark green with a reddening of some of the leaves commencing on the under surface. This latter symptom is strongly reminiscent of potassium deficiency as exhibited in strawberries.

Lack of potassium was evidenced by weak spindly plants, leaves much reduced in size with severe burning of the foliage extending from the base two-thirds up the plant. The variety Mrs. Elford was affected the worse.

In the variety Mrs. Elford, the withdrawal of phosphorus from the nutrient solution produced weak spindly plants, with the lower leaves a dull reddish-purple. Later, these leaves died and became a dark brown, easily distinguished from the light brown dead leaves, produced from excessive feeding of nitrogen.

In the variety Marie Adelaide the withdrawal of phosphorus produced weak plants with the upper leaves a dull dark green, the lower leaves somewhat faded in colour and characterized by a red spotting. In a general way, the response of the three varieties to the nutritional treatments was similar, although there is some indication that response may be qualified in degree and character by variety. There is the possibility that in a finer sense it may be necessary to group varieties according to their nutritional requirements.

The addition of potassium to the normal solution produced strong vigorous plants with no chlorosis or burning of the foliage. The general colour of the foliage was somewhat light green.

In Table 5 are tabulated data regarding growth and bloom. Excessive feeding of nitrogen as in series one produced plants with a large number of blossom buds but had a tendency to delay the time of blooming. Reduction of nitrogen in the solution produced a much smaller number of blossom buds and also reduced growth as evidenced by the height. Increasing nitrogen and potassium together caused a much larger production of blossom buds than when nitrogen alone was increased. Vigour, as represented by height of plant, was also increased, along with the size of bloom. These plants were also somewhat earlier in coming into bloom. The

addition of nitrogen and phosphorus to the normal solution caused a very large decrease in blossom buds as compared with increasing the nitrogen alone in the variety Marie Adelaide, and a marked stunting of the plants, but in the variety Mrs. Elford the treatment did not have such a marked effect.

The withdrawal of potassium from the solution caused a marked reduction in the vigour, the number of blossom buds and the size of bloom. The withdrawal of phosphorus from the solution had a similar effect as the withdrawal of potassium in causing a stunting of the plants, a reduction of blossom buds and a reduction in the size of bloom. Additional increments of potassium caused an increase in blossom buds and in the size of bloom but the number of bloom was not as large as when nitrogen and potassium were increased together.

TABLE 5.—GROWTH AND BLOOM DATA

Mrs. F. C. Elford

Series	Average height in inches	Average number of blossom buds per plant	Date of blooming	Average size of bloom	Colour
				in.	
1	55	91	Oct. 23	$3\frac{1}{4}$	Light pink.
2	48	54	Oct. 25	3	Slightly darker than No. 1.
3	62	172	Oct. 21	$3\frac{1}{2}$	Not quite as deep as No. 2.
4	47	72	Oct. 23	3	Light pink.
5	51	91	Oct. 19	3	Lighter than Ser. 1.
6	42	49	Oct. 22	$2\frac{3}{4}$	Very pale, almost white.
7	39	24	Oct. 22	$2\frac{3}{4}$	Deeper in color than No. 2.
8	50	97	Oct. 24	3	Deepest color of the series.
			Marie Adelaide		
1	47	95	Oct. 28	3	Orange.
2	44	53	Oct. 27	3	Ochraceous orange.
3	51	142	Oct. 23	$3\frac{1}{2}$	Orange to ochraceous orange.
4	40	66	Oct. 23	3	Light orange.
5	36	19	Oct. 27	3	Orange.
6	32	27	Oct. 25	$2\frac{3}{4}$	Very light orange.
7	37	26	Oct. 26	$2\frac{3}{4}$	Ochraceous orange.
8	46	103	Oct. 26	$3\frac{1}{2}$	Ochraceous orange.

Colour of Bloom

As in the variety Sir William Clark the fertilizer treatments had a considerable effect upon the production of depth of colour in the bloom.

In general, it may be said that increased feedings of nitrogen interfered with colour development, while increased feedings of potassium brought about the highest and richest bloom colour. Increased concentrations of phosphorus interfered with colour development while deficient phosphorus feeding increased the depth of colour.

Deficient potassium feeding was characterized by the greatest lack of colour development of the group. Development of bloom colour in Chrysanthemums is dependent on an adequate potassium supply. Not

only must the potassium be adequate in total amount but in its relative concentration to nitrogen and phosphorus. Thus excessive feeding of nitrogen or phosphorus will interfere with colour production even though a sufficient total amount of potassium is available if the ratio between the available potassium and these two elements is wide.

Chemical Data

Although no detailed ash analyses were made of plants from this experiment certain micro-chemical and colorimetric tests were made which to a certain extent bear out the analysis made on the former experiment. The results are tabled below:—

Series	Part of plant	Nitrate	Phosphorus	Potassium
1	Leaves	Low	Medium	
2	Leaves	Trace	Low	
3	Leaves	Very heavy	Medium	
4	Leaves	Negative	Medium	
5	Leaves	Negative	Medium	
6	Leaves	Negative	High	
7	Leaves	Medium	Low to medium	
8	Leaves	Medium	Medium	
1	Stems	High	Low	Heavy
2	Stems	Between low and medium	Low	Medium to heavy
3	Stems	Medium to high	Low	Extremely heavy
4	Stems	Trace	Medium	Medium
5	Stems	Trace	Medium to high	Medium
6	Stems	Medium to high	Medium	Fair to medium
7	Stems	Medium	Very low	Fair to medium
8	Stems	Low to medium	Low to medium	Very heavy

Increased nitrogen feeding as in Series I did not produce high nitrate-nitrogen in the leaves. This result might be expected from the colour of the foliage found in this series. However, the high nitrogen feeding was reflected in high nitrate-nitrogen in the stems. When both nitrogen and potassium feeding was high as in Series 3, nitrate-nitrogen was high in the leaves and medium in the stems. A narrow nitrogen potassium ratio in the nutrient solution appears necessary for an efficient translocation of the former element.

Additional increments of phosphorus in the nutrient solution gave negative to low results for nitrate-nitrogen in both leaves and stems.

Deficient potassium feeding gave negative nitrate-nitrogen results in the leaves and medium to high determination in the stems again showing the need of potassium in the translocation and metabolism of nitrogen. Deficient phosphorus feeding produced medium nitrate-nitrogen in both leaves and stems. In the detailed ash analysis it will be remembered that low phosphorus feeding produced high potassium in plant ash.

Additional increments of potassium in the nutrient solution produced medium nitrate in both leaves and stem.

Heavy potassium feeding was reflected by high potassium in the stems of the plants. Additional increments of phosphorus in the solution somewhat reduced the amount of potassium in the plant stems. This is in

line with the ash analysis where it was shown that heavy phosphorus feeding depressed the amount of potassium in the ash. Deficient potassium feeding resulted in low potassium in the plant stems. Very slight differences were evident in the phosphate content of the leaves when estimated colorimetrically. In the stems high phosphorus feeding was reflected by higher phosphorus in the plant tissue. Deficient phosphorus feeding was reflected by low phosphorus in the plant stems. Deficient potassium feeding brought about somewhat higher phosphorus concentration in the stems. This is similar to the negative correlation between phosphorus and potassium found in the ash analysis.

EXPERIMENTS IN RIVER SAND

In addition to the foregoing experiments the varieties Marie Adelaide and Sir William Clark were grown in beds in river sand planted 10 inches by 10 inches and subjected to four different nutritional treatments.

It was considered that these conditions would more closely approximate commercial planting and demonstrate whether or not it would be feasible to use sand as a growing medium in a commercial way.

The four nutritional solutions employed were as follows:—

1. Normal solution + (N + K) × 3
2. Normal solution + K × 3
3. Normal solution + N + 3 K
4. Normal solution + K × 2.

All four treatments produced strong vigorous plants with bountiful bloom.

Series 1 was characterized by possessing the best foliage there being no mottling, chlorosis or burning. Series 2 was somewhat less vigorous with smaller leaves and the foliage somewhat lighter in colour. There was also a slight amount of mottling on the lower leaves. Series 3 and 4 were quite similar to series 1 in growth and vigour but the mottling on the lower leaves was somewhat more severe than in Series 2.

The intensity of bloom colour was correlated with a high potassium nitrogen ratio in the nutrient solution; that is the series ranked in the order 2, 3, 4, 1.

These results are similar to those found where plants were grown in ground sand-stone in pots and subjected to similar nutritional treatments. The high potassium feeding in Series 2, 3 and 4 although producing more highly coloured bloom did not produce as attractive foliage as in Series 1, the foliage was somewhat light green in colour and characterized by slight mottling of the lower leaves, as described previously in this paper. These plants compared quite favourably with plants grown in soil and handled in a commercial way. The foliage was devoid of the considerable scorching and chlorosis that marred the ornamental value of the plants growing in soil.

Summary

1. Three varieties of Chrysanthemums, Sir William Clark, Marie Adelaide, and Mrs. F. C. Elford, were grown in sandstone in pots and fed different nutrient solutions. The two former varieties were also grown in beds in river sand under nutritional treatments.

2. Definite foliage injuries were associated with a high nitrogen potassium ratio in the nutrient solution. Chrysanthemums are apparently high potassium feeders and a nitrogen-potassium ratio of 1 to 2 in the nutrient solution produced fine vigorous plants.

3. High phosphorus feeding in the presence of a high nitrogen potassium ratio increased the severity of foliage injuries.

4. Foliage symptoms were obtained for deficient phosphorus and deficient potassium treatments which should prove of value in diagnosis.

5. Yield data indicate the possibility of reduced flower bud formation and reduction in the size of bloom due to excess phosphorus feeding.

6. There is some indication that response to nutritional treatments may be qualified in degree and character by variety and it is suggested that it may be necessary to group varieties according to their nutritional requirements.

7. Fertilizer treatments had a marked effect upon the production of depth of colour in the bloom. Development of bloom colour in chrysanthemums is dependent on an adequate potassium supply, not only in total amount but in relation to the amount of nitrogen or phosphorus available.

8. Ash analysis of the plant top revealed the marked influence on the composition of ash and dry matter of the various treatments.

9. A negative correlation of the nitrogen-potassium ratio on the accumulation of potassium, calcium, magnesium and phosphorus in plant ash was revealed.

10. Antagonism between potassium and phosphorus was revealed, similar to that reported by the authors in studies on fragaria.

11. Foliage troubles and lack of development of bloom colour were associated with low potassium in plant ash, high calcium, magnesium or phosphorus, brought about by widening the nitrogen-potassium ratio in the nutrient solution or by increasing the concentration of phosphorus.

12. Microchemical and colorimetric tests of plant tissue gave the following results.

High nitrogen feeding was reflected in accumulation of high nitrate-nitrogen in the stems at the expense of the foliage. A narrow nitrogen-potassium ratio in the nutrient solution appears necessary for an efficient translocation of the former element.

Antagonism between potassium and phosphorus was revealed as in the ash analysis.

High potassium and high phosphorus feeding were reflected by a high test for these two elements in the plant tissue.

13. Plants grown in river sand and fed nutrient solutions compared quite favourably with plants grown in soil and handled in a commercial way.

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Résumé

Etudes de nutrition sur les chrysanthèmes. H. Hill, M. B. Davis et F. B. Johnston, Ferme expérimentale centrale, Ottawa, Canada.

Trois variétés de chrysanthèmes, "Sir William Clark", "Marie Adélaïde" et "Mrs. F. C. Elford" ont été cultivées dans du grès en pots, où elles recevaient différentes solutions nutritives. Les deux premières ont aussi été cultivées en couche dans du sable de rivière, sous des traitements nutritifs différents. Les auteurs constatent qu'une proportion élevée d'azote-potassium dans la solution nutritive abîme le feuillage. Les chrysanthèmes paraissent exiger beaucoup de potassium, et une proportion relative d'azote-potassium de 1 à 2 dans la solution nutritive a produit de belles plantes vigoureuses, tandis qu'une forte quantité de phosphore jointe à une forte proportion relative d'azote-potassium, augmentait la gravité des avaries sur le feuillage. Les symptômes paraissant sur le feuillage sous les traitements déficitaires en phosphore et en potassium ont été notés et devraient servir à établir un diagnostic. Les données du rendement indiquent qu'il est possible qu'un excès de phosphore entraîne une réduction dans la formation de boutons à fruits ainsi que dans la grosseur des fleurs. Certains symptômes paraissent indiquer que l'action exercée par les traitements nutritifs varie en degré et en caractère suivant la variété et il est possible qu'il soit nécessaire de grouper les variétés, suivant leurs besoins nutritifs. Le traitement aux engrais chimiques a exercé un effet marqué sur la nuance de la couleur de la fleur. Le développement de la couleur de la fleur chez les chrysanthèmes est réglé par la quantité de potassium présente, non seulement par le montant total de potassium, mais aussi par la relation qui existe entre cette quantité de potassium et celle d'azote ou de phosphore assimilable. L'analyse des cendres de la tige de la plante a révélé l'effet sensible des différents traitements sur la composition de la cendre et de la matière sèche. Une corrélation négative de la relation azote-potassium sur l'accumulation de potassium, de calcium, de magnésium et de phosphore dans la cendre de la plante a été révélée. Un antagonisme entre le potassium et le phosphore a été noté, semblable à celui qui a été signalé par les auteurs dans leur travail sur le Fragaria. Les maladies du feuillage, le développement imparfait de la couleur de la fleur s'associent à la faible teneur en potassium dans la cendre de la plante, à la proportion élevée de calcium, de magnésium ou de phosphore, provoquée par l'élargissement de la relation azote-potassium dans la solution nutritive ou par l'augmentation de la concentration du phosphore. Des essais michrochimiques et colorimétriques du tissu de la plante ont donné les résultats suivants:—Une forte nutrition azotée a résulté en l'accumulation d'azote-nitrate dans les tiges, aux dépens du feuillage. Une relation étroite d'azote-potassium dans la solution nutritive paraît être nécessaire pour assurer une bonne translocation du premier élément. Un antagonisme entre le potassium et le phosphore a été révélé, de même que dans l'analyse de la cendre. Un apport considérable de potassium et de phosphore a provoqué un titre élevé de ces deux éléments dans le tissu de la plante. Les plantes cultivées dans le sable de rivière et qui recevaient des solutions nutritives soutenaient très avantageusement la comparaison avec les plantes cultivées dans de la terre et qui étaient traitées de la façon commerciale habituelle.

CONTROL OF THE NORTHERN FOWL MITE

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In view of the increase of the northern fowl mite *Liponyssus sylviarum* C. & F., experimental work was inaugurated at Macdonald College this year, the outline of which includes the control of the mite on the birds, on the perches and dropping boards and in the pens and houses. This work is incomplete, but as one phase has shown satisfactory results, it has been thought advisible to prepare this preliminary paper in order that others may avail themselves of the information.

A mixture of naphthalene flakes one part and vaseline two parts, has given 100% control on birds and on perches. The naphthalene should be thoroughly ground up in order to facilitate mixing and application, and then stirred into the vaseline. A small amount was applied around the tail and vent, as mites invariably congregate in this area; it was also applied to the perches, in which case none was placed on the birds. Repeated tests have been made, all of which have been correspondingly satisfactory.

Dichloricide and vaseline, in the same proportions, has also given satisfactory results. There are, however, two points in connection with its use which make it less desirable than naphthalene, namely, it costs more and tends to liquify the vaseline, which makes its application rather more difficult.

For some time, Black Leaf 40 (nicotine sulphate) has been used on perches in the control of the northern fowl mite, but comparative tests in the laboratory indicate that its action is slower than either that of naphthalene or dichloricide, and where a large area is to be covered, its cost is considerable.

It is of interest to note that naphthalene and vaseline has also been used against the body louse (*Eomenacanthus stramineus* Nitzsch) of the hen with good results. It acts rather more slowly on lice, and it should be applied to different parts of the bird. Lice do not, as a rule, show the same tendency to confine themselves to definite areas of a bird, as seems to be the habit in the case of the northern fowl mite, especially when the infestation is not severe. The fumes of naphthalene are apparently not as lethal to lice as they are to mites.

Résumé

Un mélange d'une partie d'écailles de naphtaline et de deux parties de vaseline a complètement supprimé la mite nordique des volailles (*Liponyssus sylvarium* C. & F.) sur les volailles et sur les juchoirs. Il est essentiel que la naphtaline soit parfaitement broyée afin d'en faciliter le mélange et l'application, puis ajoutée à la vaseline. Il en a été appliqué une petite quantité autour de la queue et de l'anus, car les mites se rassemblent invariablement dans cette région; on l'appliquait également aux juchoirs et dans ce cas on n'en mettait pas sur les oiseaux.

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THE ECONOMIC SITUATION

PREPARED IN THE AGRICULTURAL ECONOMICS BRANCH, DEPARTMENT OF AGRICULTURE, OTTAWA, FROM BASIC DATA COLLECTED BY THE DOMINION BUREAU OF STATISTICS

Indexes of business conditions in Canada continue to reflect a certain degree of stability. The index of wholesale prices was 72.3 in August as compared with 72.0 in July, the gain being entirely due to strength shown in the vegetable products group. Sub-indexes for other groups were either slightly lower or unchanged.

Retail Prices.—The index of retail prices, rents and costs of services rose fractionally fractionally from 78.4 in July to 78.7 in August. The chief factor in this increase was an advance in the prices of foods, the index rising from 68.4 to 69.3.

Physical Volume of Business.—The physical volume of business rose sharply in August when the index reached 99.0 as against 95.7 in July. The index of industrial production was 99.8 in August compared with 95.6 in July. In the mineral production group, consistent gains were registered and the index rose from 117.2 in July to 135.7 in August. Manufacturing showed a slight increase, the index rising from 99.0 to 100.7. Output of foodstuffs rose from 91.8 to 93.8. Tobacco releases advanced from 123.4 to 145.7. The forestry products indexes were also higher. Imports of crude petroleum advanced sharply. Indexes of construction and carloadings were also above those for July. The index of agricultural marketings rose from 148.8 to 172.8, due mainly to a larger movement of grains. Cold storage holdings were slightly above those in July.

Agricultural Products.—The index of wholesale prices of Canadian farm products advanced from 60.0 to 61.6. Prices of grains were considerably higher and this index rose from 57.8 to 60.7. This was the chief factor in the higher total index because the index of animal products declined fractionally from 63.7 in July to 63.1 in August. The position of wheat has improved materially during the past few months. Smaller European crops are reported as compared with those of 1933. The Bureau of Statistics has forecast a crop of 277,304,000 bushels in Canada as compared with an unrevised estimate of 269,729,000 bushels in 1933. Drought has reduced the United States crop to 493 million as compared with 528 million bushels in 1933, or about 60% of an average crop. It is anticipated that Canada may be called upon to supply half of the world demand for wheat which Mr. Broomhall recently estimated at 576 million bushels. The prospect, therefore, is for material reduction of surplus stocks in Canada before the end of the present crop year. Preliminary estimates indicate that the oat crop will be 344,746,000 bushels as compared with 307,478,000 bushels in 1933. Barley production is estimated at 68,000,000 bushels as against 63,359,000 last year and the rye crop is placed at 6,523,000 bushels whereas 4,327,000 bushels were grown in 1933. Average yields per acre have been slightly higher than in 1933 despite drought conditions in wide areas.

Exports of cattle during 1934 to September 20th were 38,928 head as compared with 36,676 in 1933. The number of cattle sold at public yards during the same periods numbered 447,552 this year as against 403,169 last year. Sales of calves were 270,578 and 234,689 head respectively. Hog marketings, on the other hand, were lower than in 1933. Total gradings were 2,132,917 for the first 38 weeks of 1934, whereas in 1933 during the same period 2,259,080 hogs were graded. Sales of sheep and lambs during 1934 have been 249,624 while 273,280 head were sold in 1933 at public yards.

Butter production for the seven months period ending July 31 was 135,540,736 pounds compared with 127,553,924 pounds during the seven months ending July 31, 1933. During the period December 4, 1933, to September 1, 1934, there were graded 658,963 boxes of cheese while in the period November 28, 1932, to September 2, 1933, gradings amounted to 763,659 boxes.

ANNUAL AND MONTHLY INDEX NUMBERS OF PRICES AND PRODUCTION COMPUTED BY DOMINION BUREAU OF STATISTICS

Year	Wholesale Prices 1926 = 100				Retail prices and cost of services (5)	Production (6) 1926 = 100			
	All commodities (1)	Farm products (2)	Field products (3)	Animal products (4)		Physical volume of business	Industrial production	Agricultural marketings	Cold Storage holdings
1913	64.0	62.6	56.4	77.0	65.4				
1914	65.5	69.2	64.9	79.0	66.0				
1915	70.4	77.7	76.9	79.2	67.3				
1916	84.3	89.7	88.4	92.3	72.5				
1917	114.3	130.0	134.3	119.6	85.6				
1918	127.4	132.9	132.0	134.7	97.4				
1919	134.0	145.5	142.4	152.5	107.2	71.3	65.5	48.1	47.1
1920	155.9	161.6	166.5	149.9	124.2	75.0	69.9	52.6	94.2
1921	110.0	102.8	100.3	108.5	109.2	66.5	60.4	65.2	86.4
1922	97.3	86.7	81.3	99.1	100.0	79.1	76.9	82.6	82.8
1923	98.0	79.8	73.3	95.1	100.0	85.5	83.8	91.4	87.6
1924	99.4	87.0	82.6	97.2	98.0	84.6	82.4	102.5	114.9
1925	102.6	100.4	98.1	105.7	99.3	90.9	89.7	97.2	108.6
1926	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0	100.0
1927	97.7	102.1	99.9	105.7	98.4	106.1	105.6	103.6	110.0
1928	96.4	100.7	92.6	114.3	98.9	117.3	117.8	146.7	112.8
1929	95.6	100.8	93.8	112.5	99.9	125.5	127.4	101.1	109.6
1930	86.6	82.3	70.0	102.9	99.2	109.5	108.0	103.0	128.4
1931	72.2	56.3	43.6	77.6	89.6	93.5	90.4	99.0	125.7
1932	66.7	48.4	41.1	60.7	81.4	78.7	74.0	114.3	120.1
1933	67.1	51.0	45.8	59.6	77.7	79.7	76.8	105.1	115.4
1933									
Jan.	63.9	43.6	35.1	57.9	79.1	68.1	62.2	56.1	112.0
Feb.	63.6	43.0	36.0	54.7	78.4	67.0	60.0	76.5	127.6
Mar	64.4	44.7	38.0	56.0	77.8	68.4	62.5	129.0	135.8
April	65.4	46.8	41.1	56.4	78.0	69.8	65.1	104.1	112.7
May	66.9	51.2	46.9	58.4	77.0	76.4	72.7	95.4	110.4
June	67.6	52.6	49.4	57.9	77.0	82.2	79.8	221.9	119.9
July	70.5	60.1	60.8	59.0	77.2	84.1	82.6	221.9	119.9
Aug.	69.4	57.0	54.9	60.5	78.6	89.8	89.5	197.2	114.2
Sept.	68.9	54.7	49.5	63.4	78.8	90.8	90.2	101.1	115.7
Oct.	67.9	51.4	44.6	62.8	77.9	88.2	87.4	70.5	112.7
Nov.	68.7	53.8	46.7	65.8	78.1	85.5	83.9	41.8	111.1
Dec.	69.0	53.3	45.3	66.6	78.4	86.2	85.1	30.7	107.6
1934									
Jan.	70.6	55.3	47.9	67.8	78.2	86.8	84.5	48.2	108.1
Feb.	72.1	58.0	49.3	72.5	78.7	86.4	84.0	67.1	98.6
Mar.	72.0	56.5	49.5	68.3	79.9	93.1	92.0	63.8	97.0
Apr.	71.1	55.4	48.7	66.6	79.4	92.6	91.4	56.9	94.5
May	71.1	56.9	51.1	66.5	78.5	99.6	99.4	130.6	126.1
June	72.1	59.3	55.5	65.6	78.2	95.8	95.2	97.2	101.2
July	72.0	60.0	57.8	63.7	78.4	95.7	95.6	148.8	116.3
Aug.	72.3	61.6	60.7	63.1	78.7	99.0	99.8	172.2	114.7

1. See Prices and Price Indexes 1913-1928, pp. 19-21, 270-289 and 1913-1931, p. 15.

2. Wholesale prices of Canadian products of farm origin only. See Prices and Price Indexes 1913–1931, p. 33, and Monthly Mimeographs 1933 and 1934.

3. Wholesale prices of grains, fruits and vegetables.

4. Wholesale prices of Animals and Animal Products.

5. Including foods, rents, fuel, clothing and sundries, See Prices and Price Indexes 1913-1928, pp. 181-185, 290-293. 1926=100.

Prices and Price Indexes 1913-1931, p. 122, and Monthly Mimeographs 1933-1934.

6. Monthly Review of Business Statistics, p. 8, and Monthly Indexes of the Physical volume of business in Canada, supplement to the Monthly Review of Business Statistics, November, 1932.

While improvement in prices of agricultural products may be noted, it is well to recognize that farm income is not evenly divided, because many farmers in drought areas have little to sell; on the whole, however, the immediate position of the farmer

is more reassuring than it was at this time a year ago. The continued improvement in industrial production gives hope for better returns from farming. Employment has, however, fallen off because of the layoff of workmen engaged in highway construction, and it must be remembered that sharp advances in prices without corresponding increase in consumers' purchasing power will result in reduction in consumption.

Reorganization in Great Britain.—The release of agricultural returns in England and Wales reveals among other things the fact that the acreage in wheat increased from 1,660,000 acres in 1933 to 1,759,000 in 1934. Acreage in sugar beets increased from 264,100 to 396,500. The number of cattle increased from 6,620,200 head to 6,659,000 and the number of pigs rose from 3,069,100 to 3,318,900. Acreage in orchard increased from 349,600 to 254,700 in 1934. Numbers of horses and sheep were lower. The area in hops, which are now under a marketing scheme, increased 900 acres this year as compared with 1933. These changes are quite significant of what is taking place in agricultural reorganization in England and Wales. Recent press reports indicate that a fruit marketing scheme is now being prepared. Conferences have been held with the fruit traders, representatives of the Jam Section of the Food Manufacturers' Federation and the canners' representatives. This scheme, like many others, is being sponsored by the National Farmers' Union and if it is decided to proceed with the plan, it is not expected that it will come into effect before the 1936 season. With the completion of a fruit marketing scheme, regulation of the marketing of most of the chief agricultural products of Great Britain will have been provided.

LA SITUATION ÉCONOMIQUE

PRÉPARÉE PAR LA DIVISION DE L'ÉCONOMIE AGRICOLE DU MINISTÈRE DE L'AGRICULTURE À OTTAWA, D'APRÈS DES DONNÉES BASIQUES RECUEILLIES PAR LE BUREAU FÉDÉRAL DE LA STATISTIQUE

Les indices du commerce au Canada continuent à révéler un certain degré de stabilité. L'indice des prix de gros était de 72.3 en août contre 72.0 en juillet; l'augmentation est due presque entièrement à la fermeté présentée par le groupe des produits de légumes. Les sous-indices des autres groupes étaient un peu plus bas ou n'accusaient aucun changement.

Prix de détail.—L'indice des prix du détail, des loyers et des frais de services, s'est élevé de 78.4 en juillet à 78.7 en août. Le facteur principal de cette augmentation est la hausse qui s'est produite dans les prix des denrées alimentaires, dont l'indice a passé de 68.4 à 69.3.

Volume physique de la production.—Le volume physique de la production s'est élevé sensiblement en août, atteignant 99.0 contre 95.7 en juillet. L'indice de la production industrielle était de 99.8 en août contre 95.6 en juillet. Dans le groupe de la production minérale, des gains constants ont été enregistrés; l'indice s'est élevé de 117.2 en juillet à 135.7 en août. Les industries manufacturières révèlent une légère augmentation, de 99.0 à 100.7. La production des denrées alimentaires s'est élevée de 91.8 à 93.8. Les expéditions de tabac ont passé de 123.4 à 145.7. Les indices des produits des forêts étaient aussi plus élevés. Les importations de pétrole brut ont sensiblement augmenté. Les indices de l'industrie du bâtiment et des chargements de wagon étaient aussi supérieurs à ceux de juillet. L'indice des ventes agricoles s'est élevé de 148.8 à 172.8, principalement à cause des expéditions plus fortes de grains. La quantité de produits entreposés au froid était un peu plus forte qu'en juillet.

Produits agricoles.—L'indice des prix de gros des produits agricoles canadiens est passé de 60.0 à 61.6. Les prix des grains étaient beaucoup plus élevés; l'indice qui les dénote est passé de 57.8 à 60.7. C'était même là le facteur principal dans le relèvement de l'indice total, parce que l'indice des produits animaux a baissé d'une fraction, de 63.7 en juillet à 63.1 en août. La situation du blé s'est beaucoup améliorée en ces quelques derniers mois. Les récoltes européennes sont inférieures à celles de 1933.

Le Bureau de la Statistique prévoit une récolte de 277,304,000 boisseaux au Canada contre une évaluation non revisée de 269,729,000 boisseaux en 1933. Aux Etats-Unis, la récolte a été réduite à 493 millions par la sécheresse contre 528 millions de boisseaux en 1933, soit 60 pour cent environ d'une récolte moyenne. On prévoit que le Canada sera appelé à fournir la moitié de la demande mondiale de blé que M. Broomhall a évaluée récemment à 576 millions de boisseaux. Une réduction sensible des stocks de surplus au Canada avant la fin de l'année actuelle de récolte est donc à prévoir. Les évaluations préliminaires indiquent que la récolte d'avoine sera de 344,746,000 boisseaux contre 307,478,000 boisseaux en 1933. La production d'orge est évaluée à 68,000,000 de boisseaux contre 63,359,000 l'année dernière et la récolte de seigle à 6,523,000 boisseaux contre 4,327,000 en 1933. Les rendements moyens par acre ont été un peu plus élevés qu'en 1933 malgré la sécheresse qui a sévi dans de grandes étendues.

En 1934, à venir jusqu'au 20 septembre, les exportations de bestiaux ont été de 38,928 têtes contre 36,676 en 1933. Le nombre de bovins adultes vendus aux parcs publics pendant les mêmes périodes de temps a été de 447,552 cette année contre 403,169 l'année dernière. Celui des veaux a été de 270,578 contre 234,689 l'année dernière. Par contre, les ventes des porcs ont été plus faibles qu'en 1933. Le total des porcs classés a été de 2,132,917 pendant les 38 premières semaines de 1934 tandis

qu'il avait été de 2,259,080 pendant la même période en 1933. Les ventes de moutons et d'agneaux en 1934 ont été de 249,624; elles avaient été de 273,280 en 1933 aux marchés publics.

La production de beurre pendant les sept premiers mois qui ont pris fin au 31 juillet a été de 135,540,736 livres contre 127,553,924 livres pendant les sept mois finissant au 31 juillet 1933. Pendant la période allant du 4 décembre 1933 au 1er septembre 1934, il s'est classé 658,963 fromages tandis que pendant la période allant du 28 novembre 1932 au 2 septembre 1933 la quantité classée avait été de 763,659.

Tout en reconnaissant l'amélioration qui s'est produite dans les prix des produits agricoles, il faut admettre que le revenu de la ferme n'est pas également réparti parce qu'un grand nombre de cultivateurs dans les régions où la sécheresse a sévi n'ont pas grand'chose à vendre. Cependant, tout considéré, la situation immédiate des cultivateurs est plus rassurante qu'elle n'était à cette époque l'année dernière. L'amélioration soutenue de la production industrielle donne l'espoir d'une augmentation dans le revenu de l'agriculture. Il y a eu diminution dans l'embauchage, cependant, parce que beaucoup d'hommes qui étaient occupés à la construction des chemins ont été congédiés et il ne faut pas oublier que les hausses de prix qui ne sont pas accompagnées d'une augmentation correspondante dans le pouvoir d'achat des consommateurs ne peuvent qu'abaisser la consommation.

La publication des rapports agricoles en Angleterre et dans le Pays de Galles révèle entre autres choses le fait que les emblavures de blé ont passé de 1,660,000 acres en 1933 à 1,759,000 acres en 1934. L'étendue plantée en betteraves à sucre est passée de 264,100 à 396,500. Le nombre de bovins, qui était de 6,620,200 est passé à 6,659,000 et le nombre de porcs s'est élevé de 3,069,100 à 3,318,900. L'étendue en vergers a augmenté de 249,600 à 254,700 en 1934. Il y a eu diminution dans le nombre des chevaux et des moutons. L'étendue en houblon, dont la vente est maintenant réglementée a augmenté de 900 acres cette année. Ces changements sont très significatifs de la réorganisation agricole qui a eu lieu en Angleterre et dans le Pays de Galles. Les rapports récents de la presse indiquent qu'on prépare actuellement un plan d'organisation du marché aux fruits. Il s'est tenu des conférences avec les marchands de fruits, les représentants de la section des confitures de la Fédération des Fabricants de Denrées Alimentaires et les représentants des conserveries. Ce plan, comme beaucoup d'autres, est lancé par l'Union Nationale des Cultivateurs (National Farmers' Union) et si l'on se décide à l'adopter, on ne prévoit pas qu'il entrera en vigueur avant la saison de 1936. Lorsque l'organisation du marché des fruits aura été complétée, presque tous les principaux produits agricoles de la Grande-Bretagne se trouveront sous un système de contrôle des ventes.

BOOK REVIEWS

LIPPINCOTT AND CARD. Poultry Production. Lea & Febiger, Washington Square, Philadelphia, Pa. Fifth Edition.

Dr. L. E. Card, the co-author of "Poultry Production" by the late Dr. W. A. Lippincott, has brought forward an extremely valuable text for all interested in the science and practice of poultry culture. The revision of text material has been ably carried out, adding to the original material carefully selected new data and thought to make the present volume of utmost value to the student and the producer of poultry on the farm, as well as the handler of poultry products in commerce. Dr. Card has made an attempt to evaluate the newer knowledge of production and marketing in such a way as to give the reader a clearer understanding of the new reference material, as well as the basic principles laid down.

It has not been the attempt of the author to completely revise the entire text at one time, but undoubtedly as time progresses this text will prove to be a very valuable part of our poultry literature. A general revision of the text has, however, been made and additional chapters dealing with new phases of the subject have been added.

The list of references, arranged according to chapter subject, places before the reader an immediate source of reference material which will be greatly appreciated by students of the subject. —W. A. Maw.

J. C. ARTHUR. Manual of the rusts in United States and Canada. Illustrated by G. B. Cummins. *XV* + 438 pages, 1 map. Purdue Research Foundation, Lafayette, Indiana, 1934.

More than fifty years ago Dr. Arthur published his first paper on the rusts. For many years thereafter his time was largely occupied with other important matters; but he never forsook the rusts. Thanks largely to his efforts, the rusts of the United States and Canada are now usually easily identified. He has rendered a great service to everyone interested in the rusts by producing this manual. He has compressed into 438 pages the information requisite to the identification of our rusts; has summarized under each species the data regarding cultures or other noteworthy points; has listed the varieties and correlations of the species, the important synonym, and the ranges. A very conservative nomenclature is followed. Excellent illustrations by George B. Cummins add greatly to the value of the book. The preface explains the essentials of life history, relationships, and nomenclature of rusts, and is followed by a list of authors of species and a short glossary. The book concludes with a host index and a rust index. This work is a monument to the achievements of Dr. Arthur in elucidating the rusts of this continent. —G. R. Bisby.

GILBERT H. COLLINGS. Commercial Fertilizers. Philadelphia, Blakiston's Son & Co. 356 pages, illus. 1934.

This book is designed as a text on commercial fertilizers for students in Agricultural Colleges. The following points are emphasized; nature of raw materials, manufacturing processes, characteristics of finished products and the use of fertilizers. Four chapters are devoted to the nitrogen carrying fertilizers, three to the phosphates, three to the potash fertilizers and one to the fertilizers carrying other elements. As a text book it is sufficiently brief, well arranged and well edited. It should be of service as a guide to the district agent, the practical farmer, and the fertilizer industry. —F. A. Wyatt